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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

SEPTEMBER 1917.

GENERAL PHYSICS.

838. *Model Tellurion.* (Engineer, 123. pp. 489–491, June, 1917.)—Working drawings and a photographic illustration are given with a detailed description of a model orrery designed by W. Wilson for instruction purposes. The motions are produced by belt driving from a central stem, special provision being made for keeping the belt taut, and for exactly adjusting the diameters of pulleys for different rotation ratios. C. P. B.

839. *New Form of Clock Synchroniser.* **F. L. Blake** and **W. E. W. Jackson.** (Roy. Astron. Soc. Canada, J. 11. pp. 175–177, May–June, 1917.)—A modification of Stewart's clock synchroniser has been installed in the Meteorological Observatory at Toronto, the improvements being chiefly in connection with the reduction of number of armatures, utilisation of current from a magneto clock instead of a local battery, and the reduction of contact sparking. Diagrams are given showing the electrical connections and arrangement of contacts. C. P. B.

840. *Calibration of New Screw-measuring Machine.* **O. J. Lee** and **H. B. Steele.** (Astron. J. 30. pp. 128–129, May 5, 1917.)—A description is given of tests of a new measuring machine designed by F. Schlesinger and made by Gaertner, of Chicago. The screw is 18 mm. in diam., and has 249 threads of 1 mm. pitch. The periodic error was found to have a max. value of 0·00013 mm., which is negligible in all work with stellar images. The progressive errors were determined for every cm. of the screw, with a temperature range, during the measurement, of 1·3 deg. C. They are small and negligible for the work in view. C. P. B.

841. *Alternating Torsion and Impact Testing-machines.* **D. J. McAdam.** (Mech. Eng. 39. p. 161, March 2, 1917. Rev. de Mét. 13E. pp. 257–259, Nov.–Dec., 1916. Paper read before the Am. Soc. for Testing Materials, June, 1916.)—A brief description is given of an alternating torsion testing-machine and of an impact testing-machine for unnotched specimens.
F. C. A. H. L.

842. *Improvements in Hot-wire Anemometers.* (Frank. Inst., J. 183. pp. 783–785, June, 1917.)—The ordinary type of electrical hot-wire

anemometer is so arranged that the wind-measuring wire forms one branch of a Wheatstone or Kelvin bridge and is kept at constant resistance, which means constant absolute temperature, while the electrical power dissipated by the wire is observed.

It is evident that if the temperature of the moving air changes during the test the "apparent" total wind velocity (at constant resistance of the test wire) will also be changed.

The present modification due to R. D. Fay is to effect an automatic compensation by making all four arms of the bridge of either tungsten or nickel wire. The two arms previously of constant-resistance wire are in the new arrangement made of two parallel tungsten wires so that a bridge A B C D will have one wire from A to B, two from A to D, one from B to C, and two from D to C. The doubled wires are longer than the single wires in a ratio *a* of, say, about 2·5. Under these conditions it will be found that if the same wind velocity acts constantly upon all six wires, and if the temperature of the wind changes, the bridge balance will be affected in such a manner that when balance is restored the total velocity is again proportional to the square of the electrical power dissipated. Or, in other words, a given set of six wires in constant surface condition requires a definite and constant temperature-elevation to obtain resistance balance for all wind-temperatures. E. G.

843. *Demonstration of a Method of Silvering Glass with Chemicals of Ordinary Purity.* **R. E. Crowther.** (Phot. J. 57. pp. 185–189; Disc., 189–190, June, 1917.)—The author here presents his process for silvering glass to alleviate the present difficulties in the way of getting optical glass silvered quickly. Four solutions are used :—I. 10 % silver nitrate in distilled water; II. 7 25 % caustic soda (stick) in distilled water; III. 28–30 % ammonia (commercial strong); IV. Reducing solution—equal volumes of A and B, where A consists of 9 gm. lump (or white crystal) sugar in 50 cm.^{3} distilled water to which is added 0·4 cm.^{3} conc. nitric acid and then 17 cm.^{3} alcohol, finally making up to 100 cm.^{3} with water; B is made by dissolving 10 gm. sugar, as in A, in 50 cm.^{3} dist. water, adding 1 gm. tartaric crystals, boiling 5 mins., cooling, adding 18 cm.^{3} alcohol, and finally diluting to 100 cm.^{3} with water.

For every 100 cm.^{3} silvering solution take 11 cm.^{3} solution I, remove 4 cm.^{3} and dilute with 15 cm.^{3} dist. water; add to the 7 cm.^{3} ammonia III, whilst shaking until just clear; then, whilst shaking, add 10 cm.^{3} solution II, and again, whilst shaking, add enough ammonia to just re-dissolve the precipitate. Finally, whilst shaking, add the diluted 4 cm.^{3} solution I, obtaining sherry-coloured, opalescent liquid. Filter and dilute to 78 cm.^{3} with distilled water. Mix 11 cm.^{3} reducing solution (IV) with 11 cm.^{3} dist. water, and add the mixture to the 78 cm. sherry-coloured silver solution, and pour immediately on to the glass, which should be 5 to 10 deg. F. warmer than the solutions. Rock vigorously and silver for two-and-a-half times the time from pouring on the mixed solutions until deposition commences. Rinse twice in distilled water, swab under tap, blot off surface water, allow to dry half an hour in warm place, and polish off the slight bloom.

The silvering is done face upwards in the dish, which in itself is a great advantage. The paper also contains the report of an instructive discussion over the details of the process. H. H. Ho.

844. *Making Glass Tubes of Precise Dimensions.* **Lambris.** (Zeits. Angew. Chem. 29. I. pp. 382–383, Oct. 20, 1916. Zeits. Instrumentenk.

Beib. No. 9. p. 80, May 1, 1917.)—K. Küppers (German Pat. 292,737; Zeits. Angew. Chem. 29. II. pp. 417–418, Sept. 22, 1916) makes glass tubes of any cross-section, round or polygonal, cylindrical or conical, by fitting a core of the precise dimensions into a glass tube approximately of the desired shape, closing the tube, evacuating it and heating it externally while turning it about its longitudinal axis, until the air pressure has forced the glass uniformly against the core; the core is then withdrawn (no particulars given), and may at once be re-used. The heating may be progressive, and the core, which can be built up of parts, may bear division marks, etc., for the direct production of graduated pipettes, measuring glasses, etc. Apparatus of this kind, which are tested in batches, have been found accurate in the laboratories of the Technical College at Aachen. H. B.

845. *Change of Internal Friction of Metals with Temperature.* **P. Ludwik.** (Zeits. Phys. Chem. 91. 2. pp. 232–247, Feb. 29, 1916.)—By internal friction R the author understands the specific tangential stress required to cause a permanent relative displacement of the particles. In liquids R would, in the first instance, depend upon the specific rate of displacement v and the temperature t, and for $v = 0$, R would be 0; in solids any previous deformation or specific shear γ has to be considered; R may be greater than 0 for $v = 0$, and will in general increase with increasing γ, though it may decrease. To eliminate γ, the metals were submitted to heat treatment. In this paper the author determines the cone-pressure hardness and plots it against a temperature-abscissa. The specimens are fused under a layer of chlorides, cast and annealed; the resulting plate is laid on a bed-plate of steel and electrically heated in a bath (oil from 20° up to 300°, nitrates up to 600°); the metals were of the highest commercial purity, the bismuth and antimony probably not pure. The load, from 5 up to 1000 kg. is applied, rapidly in 15, or slowly in 300 seconds; the cone-angle is 90°. A nearly steady decrease of the hardness with rising temperature was observed in all cases, the curves being slightly concave (hardness-decrease slower at higher temperatures) in the case of Sn and Bi, more concave in the case of Cd, Pb, Zn, Sb, somewhat S-shaped in the case of Al and Cu. Irregularities due to molecular transformation did not seem of importance. All the metals retained considerable hardness near their melting-points, when the internal friction of the solid suddenly passed into the viscosity of the liquid; Sn and Bi still showed near the melting-point 10 % of their R-values at 20°, Pb 7 %, Cd 2 %, Zn 1·5 %. When the curves of the different metals are combined in one diagram, they intersect; equal and homologous temperatures must thus be distinguished. The hardness change is also influenced by the rate of application of the load. H. B.

846. *Mode of Flow in Crystalline Substances.* **G. Tammann.** (Zeits. Anorg. Chem. 92. 1/2. pp. 37–46, June, 1915.)—Flow has been ascribed to a partial melting. When a crystalline substance is compressed by a piston which does not fit closely, it has been suggested, melting takes place at much lower pressure than with a tightly-fitting piston. Theoretical considerations have been based on such mistaken experiments. According to Poynting the untight piston sinks a little, when such partial melting takes place; the liquid then crystallises, and the piston is raised or lowered in accordance with the resulting volume-change. Ostwald argued in a similar way, starting from Schiller's view that external pressure on a liquid raises the vapour pressure. Niggli (1915) reached the same conclusion by wrongly applying thermo-

dynamical considerations. How stress upon a crystal influences the equilibrium between a crystal and its melt as to pressure and temperature had already been shown by Gibbs and Riecke. Tensile and compressive stresses, even when reaching the elastic limit, have very little influence, which rarely will exceed the errors of observation. When ice is compressed by a leaky piston it begins to flow at an indefinite pressure which depends upon the cross-section ; a sudden drop of the piston occurs only after the pressure p reaches the value corresponding to the temperature ; the escaping water then freezes under 1 kg./cm.^{2}. The ice under stress would melt under a pressure a little smaller than p, but the experimental verification is difficult. Microscopical observation shows that the cause of the flow and plasticity is the formation of small polyhedra or lamellæ which slip over one another. H. B.

847. *Melting-point of Compressed Crystals.* **M. Hassellblatt.** (Zeits. Anorg. Chem. 93. 1. pp. 75–83, Aug. 19, 1915.)—Like Tammann [see preceding Abs.] the author criticises the arguments of Poynting, Ostwald, and Niggli. The cycle is not reversible. Either there is, at a certain point of a crystal, a pressure acting in all directions, opposed at the surface by the counter-pressure of the adjacent phase ; or the counter-pressure is missing, there is deformation by one-sided load ; in this latter case, when the liquid can escape, there is only tension (*Spannung*), not counter-pressure. Crystals under pressure cannot be in direct contact with a melt which is not under pressure. Indirectly, however, the condition may be imagined by realising the pressure gradient with the aid of an intermediate phase. The author describes an apparatus of this kind, an osmotic cell placed within a vessel, filled with the melt and itself containing the same melt and also crystals of the substance, whilst the melt outside is further charged with solution of some indifferent substance. The only analogous case in nature would be that of freezing cell-sap. H. B.

848. *Alternating-stress Experiments.* **W. Mason.** (Inst. Mech. Eng., J. 4. pp. 121–159 ; Disc., 159–196, May, 1917. Engineering, 103. pp. 187–190 ; Disc., 184–185, Feb. 23, and pp. 211–214, March 2, 1917.)—A systematic measurement of cyclic strains during complete alternating-stress tests of mild steel has been made in a machine specially designed to carry out experiments under repeated torsion or bending, or under repeated simultaneous bending and torsion at speeds varying from 2 to 200 cycles per min. The steel used was the B.A. 0·12 % carbon dead-mild steel [see Abs. 884B (1916)] and the results show that under small ranges of stress there was a narrow hysteresis loop indicative of elastic hysteresis. In repeated bending the max. shear stress was nearly the same as in repeated torsion, indicating that shear stress is the prime cause of elastic failure in both cases and that Guest's law holds for this steel. A feature of the range of "strain-cycles endured" curves is the rapid increase of the cyclic strain at the beginning of application of cycles at a given range, greater than that at which the elasticity remained unimpaired, and the subsequent smaller rate of increase. It seems possible that the real max. stresses are somewhat higher at rapid rates of reversal on account of time effects. The following conclusions are derived from the results :—Mild steel will endure a very large number of reversals of a range stress, considerably greater than the range at which the extra-elastic strain appears, which induces a considerable range of extra-elastic strain. Assuming uniformly varying stresses, the range of stress which induces fracture is greater for solid than for hollow specimens. Resting a specimen

in which extra-elastic strain has been developed results in a reduction of the range of strain. This effect is similar to that of hardening after strain, and is not of the nature of recovery of elasticity. F. C. A. H. L.

849. *Elastic Constants of Antimony and Tellurium Wires.* **P. W. Bridgman.** (Phys. Rev. 9. pp. 138–141, Feb., 1917.)—Describes the special methods used in the preparation of these metals in the form of wire, the process of extrusion through a steel die under the influence of high pressure and a *rapid* rise of temperature being found most satisfactory in the case of Sb. Young's modulus was determined by cementing lengths of wire into the chuck of the milling attachment of a jeweller's lathe, loading the end with a rider of known weight, and observing the deflection of the free end with a cathetometer. By rotating the chuck the effect of inequalities of cross-section was eliminated. The length of the wires was 7·5 to 9 cm., the load was 0·014 gm., and the deflection varied from 0·3 to 0·7 mm. The rigidity was measured by attaching coaxially to the wire with cement a glass fibre, twisting wire and glass together, and observing simultaneously the amount of twist of glass and wire. Then by using the glass fibre separately as a torsion pendulum with a suspended disc, the moment of the force for a given amount of twist of the glass was found, and so the twisting force of the wire . It was not possible to use the wire directly as a torsion pendulum on account of its extreme fragility. The values of the constants found are as follows :—

	Young's Modulus.	Rigidity.
Antimony	$7{\cdot}8 \times 10^{11}$	$2{\cdot}0 \times 10^{11}$
Tellurium	$4{\cdot}1 \times 10^{11}$	$1{\cdot}54 \times 10^{11}$

These values are computed on the assumption of perfect isotropy. It is apparent, however, that the relation between the constants for Sb is not one that is possible for an isotropic material, and the values obtained, therefore, are regarded as only applicable in computing strains of the same types as those used in the tests and as affording an indication of the order of magnitude of the constants which, it is pointed out, are the same as those found for ordinary grades of glass. J. W. T. W.

850. *Air-resistance Measurements.* **V. Valcovici.** (Comptes Rendus, 165. pp. 147–149, July 23, 1917.)—In apparatus for the determination of the resistance offered by the air to the motion of a body through it, it is usual to place the body at the end of an arm long in comparison with the dimensions of the body, and to assume that the motion is, to first approximation, equivalent to a rectilinear translation. The errors involved in this assumption are here mathematically investigated, and it is shown that in the case of a rectangular plate, the point at which the relative speed of the plate and the air is zero is displaced from the centre towards the side remote from the axis of rotation. The cases of a circular and of an elliptic cylinder are similarly considered. J. W. T. W.

851. *Graphical Method of Drawing Trajectories for High-angle Fire.* **W. E. Dalby.** (Roy. Soc., Proc. 93. pp. 333–347, July 2, 1917.)—In a previous communication [Abs. 511 (1916)] the author described a graphical method for finding the time of flight, the range, the angle of elevation, in fact, the elements of a trajectory, having given the curve of resistance as a function of the velocity, and assuming that the density of the air was constant at all points along the trajectory. The method was therefore only applicable to

trajectories of low altitude. In the present paper a graphical method is described for obtaining a series of points on a trajectory of high altitude, taking into account the variation of the density of the air with height. Providing that two curves are given, the problem may be solved approximately by a process of step-by-step integration, using the graphical method previously described to obtain time-velocity and time-distance curves. These two curves are: (1) A curve showing the resistance in air of standard density of a shell of standard form fired under standard conditions, the resistance being shown as a function of the velocity. (2) A curve showing the tensility of the air as a function of the height. The tensility at a given height is the ratio between the density of the air there and the standard density at sea-level. The solution of the problem is given mathematically and then graphically, being illustrated by an example giving in detail the work of determining a point on any particular trajectory. Numerous curves and tables are included in the paper. H. H. Ho.

852. *Fundamental Hypotheses on the Mechanics of Pulverulent Masses.* **J. Boussinesq.** (Comptes Rendus, 164. pp. 657-663, April 30, 1917.)—The author first gives a *résumé* of the mechanical principles usually accepted for pulverulent masses such as a heap of sand. There exists for each particle of a mass of sand, when conceived as isolated from its neighbours, a natural condition in which no action is exercised between the grains, each individual being then subjected to atmospheric pressure. Departing from this natural state the particles can undergo infinitesimal contractions thereby experiencing a normal pressure. In addition the particles are capable of finite deformations without modification of density which are reducible to three principal dilatations in three directions at right angles, corresponding to three principal pressures. A pulverulent mass acquires a rigidity, or resistance to slip, when certain relations between the above forces prevail, and each such mass possesses a unique coefficient of slip. The author then proceeds to discuss mathematically these various relationships. He finds that the principal positive dilatation for each particle has an upper limit Δ expressed by the formula $\Delta = \sin \phi/2m$, where ϕ is the interior angle of friction, and m is the unique coefficient referred to above; this upper limit Δ may be styled the elastic limit of the particular pulverulent mass. The author concludes that a pulverulent mass possesses a rigidity mp proportional to the average pressure p, which average pressure, however, is not simply a consequence of the cubical contraction as would seem reasonable at first sight, being proportional to the sum of the squares of the three principal deformations.
H. H. Ho.

[Numerous papers are published in following numbers of the *Comptes Rendus* in which the principles set forth above are applied in the solving of specific problems.—Ed.]

853. *On a Proposition of Statistical Dynamics and its Extension in the Quanta Theory.* **M. Planck.** (Preuss. Akad. Wiss. Berlin, Ber. 24. pp. 324–341, 1917.)—In his theory of the Brownian movement, Einstein [Abs. 743 (1906)] has developed a very fruitful proposition for the stationary state of a large number of similarly constituted systems which are subjected to small accidental external disturbances. Later this has been generalised by Fokker [Abs. 1087 (1914)] that the effect of an external disturbance is dependent upon the state of the system. Fokker, however, has communicated only the terms of his generalised proposition without adding a proof, this being

deferred. Owing to the non-appearance of the latter, which is important for statistical dynamics, the present author now puts forth a proof. He has also attempted to develop the proposition from the standpoint of the quanta theory so as to afford a vantage point for the determination of the stationary state. A reservation has to be made, however, for if the view be adopted that the quanta theory only admits of the so-called static states of systems when properly defined, *i.e.* definite rotation velocities and definite amplitudes, then the proposition above becomes meaningless, since it concerns small alterations in state which cannot occur if the state be already from the outset defined by a quanta number. The previous mode of investigation has therefore to be abandoned, since finite changes from one static state to another have to be studied. If it be accepted in the quanta theory that the processes of absorption follow the laws of the classical theory, and that only the particular quanta demands for emission are to be satisfied, then the Einstein-Fokker proposition is shown to be extremely serviceable. The latter assumption has therefore been made, although the author does not claim it to be absolutely correct from the physical standpoint, since it gives a series of phenomena, which appear rather to support the view that the states of systems only alter spasmodically. The author, in spite of every effort, has not yet succeeded in finding a definite proof for the inadmissibility of continuous changes of state ; on the contrary, his investigation of some of the phenomena in dispute has shown these to be completely inexplicable on the classical absorption laws, and he believes himself to be justified in adopting this standpoint so long as no direct contradiction with experience is given, as this will be the most certain way of arriving at the limits of the validity of the classical theory. If the absorption laws retain their validity, then a special hypothesis will be requisite for emission phenomena, which the author develops in the paper and claims to be of far-reaching service. Finally, the Einstein-Fokker proposition has been extended for the case of the state of a system depending not only on one parameter, but on several.

H. H. Ho.

854. *Laws of Elastico-Viscous Flow.* **A. A. Michelson.** (Nat. Acad. Sci., Proc. 3. pp. 319–323, May, 1917.)—When a solid is subjected to a strain beyond the elastic limit, its behaviour may be summarised as follows :— (1) The application of the stress results in a rapid elastic yield, which, if inertia be negligible, is practically instantaneous. If the stress be now removed, the specimen returns to its former position. (2) This is followed by a slower yielding whose rate, if the stress is not too great, diminishes with time, and which ultimately attains a constant value which may be zero. If the stress be now removed, the specimen returns almost instantaneously to a point short of its original position, and then continues at a much slower rate, and ultimately comes to rest at a point short of its original position. If the stress is too great, the slow yield may increase until rupture occurs.

The paper afterwards gives a provisional attempt to formulate the behaviour of substances under stress by the simplest expressions which have been found to satisfy all the essential requirements. The formulæ given are sufficiently general to include every case thus far examined, including materials of widely different properties, such as lead, tin, copper, aluminium, zinc, iron, steel, quartz, glass, calcite, limestone, slate, marble, wax, pitch, gelatine, and rubber. It may, however, be expected that a more thorough investigation will require modification in the formulæ, which may be made to fit special cases with greater accuracy.

The type of strain selected for this investigation is the torsion of cylindrical rods, as this is the only strain in which the form remains unaltered. It is very probable that the laws governing this special type may be made to include other distortions such as extension, compression, bending, etc. The changes to be expected from temperature and pressure could be taken into account by appropriate alterations in the value of the "constants" which enter into the formulæ. The torque was applied by weights in scale pans whose cords came from a light pulley, of radius 8 cm., on the specimen which had a diam. of 12 mm. at the ends, the intervening portion being 4 mm. in diam. and 75 mm. long. The tests consisted in measuring the angular position of the pulley by a micrometer at intervals of one minute while under a constant torque.

The behaviour of any solid under stress may be considered as the resultant of four elements: (*a*) The elastic displacement, (*b*) the elastico-viscous displacement, (*c*) the viscous displacement, (*d*) the lost motion. These displacements are represented respectively by—

$$C_1 P e^{h_1 P},\ C_2 P e^{h_2 P}\ (1 - e^{-a\sqrt{t}})$$

$$C_3\ (P e^{h_3 P} t + P_0 e^{h_3 P_0} t_0)^\rho - (C_3 P_0 e^{h_3 P} t_0)^\rho,$$

in which P is the torque and t the time. The lost motion, the return and the temperature effects are also discussed. E. H. B.

855. *Resistance to Motion of Lamina, Cylinder, or Sphere in Rarefied Gas.* **F. J. W. Whipple.** (Phys. Soc., Proc. 29. pp. 250–257; Disc., 257–258, June, 1917.)—This mathematical investigation is carried out on the assumptions that the free paths of the particles of the gas are long compared with the dimensions of the moving body, and that the motion relative to the body of the particles which rebound from it depends only on its temperature. It is shown that, if v, w be the components of velocity perpendicular and parallel to the surface of a lamina, the corresponding components of the resistance are $(4 + \pi)\sqrt{(3/2\pi)}pv/V$ and $2\sqrt{(3/2\pi)}pw/V$, where V is the standard (root-mean square) speed of the gas-particles and p is the gas pressure.

The resistance to the motion of a cylinder or a sphere is found to differ very slightly from the resistance to a lamina occupying the central section. The formulæ are applicable to the problem of the damping of the oscillations of a system suspended in a rarefied gas. **G. D. West** called attention to the fact that the author's value for the ratio of normal to tangential resistance of a lamina was in good agreement with that previously obtained by Knudsen. **D. Owen** welcomed this work as assigning a more precise figure for the constant to be used in reducing observations for pressure-measurement by the method of damping. **P. E. Shaw** considered the results obtained likely to prove very useful. Each of the three cases (lamina, cylinder, and sphere) is applicable to well-known special high-vacuum apparatus. The pressure existing at any time in a sealed-off high vacuum cannot be found by the McLeod gauge; the use of the electric discharge method is very rough, and may introduce ionisation, de-occlusion, and other troubles. When the apparatus has a system moving with pendular or torsional vibration the logarithmic decrement method is simple in the extreme and requires no accessory plant. E. H. B.

856. *Tolman's Transformation Equations, Photoelectric Effect, and Radiation Pressure.* **S. Karrer.** (Phys. Rev. 9. pp. 290–291, April, 1917.)—This

paper points out two important cases in which the transformation equations of Tolman's principle of similitude give results which are in accord with present knowledge.

(1) Assume we know from experiment that the kinetic energy E of the electrons emitted from a metal under the influence of light, *minus* a constant E_0 is only a function $f(n)$ of the frequency n of the incident light, and is independent of the intensity of the light and of the temperature and special properties of the metal. This gives $E - E_0 = f(n)$. Then from Tolman's equations it follows that

$$E' - E_0' = (E - E_0)/x \text{ and } n' = n/x,$$
$$E' - E_0' = f(n'),$$
$$(E - E_0)/x = f(n/x)$$
$$E - E_0 = xf(n/x) = f(n).$$

x being arbitrary, this functional equation must hold for every value of x. Its solution will be of the form, $f(n) = hn$, where h is a constant; hence $E - E_0 = hn$, which is Einstein's photoelectric equation.

(2) Apply the transformation equation to get the relation between the pressure exerted upon a body by the radiation incident upon it and the density of that radiation. Assume experiment shows that the pressure p depends only on the energy-density E of the radiation, then $p = f(E)$, and since $p' = p/x^4$ and $E' = E/x^4$, $f(E)$ must satisfy the functional equation $p = x^4 f(E'/x^4) = f(E)$. That is $p = f(E) = kE$, where k is a constant. It is known that p varies as E. E. H. B.

857. *Experimental Inquiry into the Laws of the Brownian Movement in a Gas.* [Miss] **A. Snethlage.** (K. Akad. Amsterdam, Proc. 19. pp. 1006–1021, 1917.)—In a former paper [Abs. 985 (1916)] some objections to Einstein's formula for the Brownian movement have been advanced by van der Waals, Jr., and the author. This formula, namely, $\bar{\Delta}^2 = 2RTB/N$, where $\bar{\Delta}^2$ represents the mean square of the displacement which a "Brownian particle" obtains per sec. in a definite direction, has been derived on the supposition that the particle meets in its movement a frictional resistance, and accordingly B is the inverse value of the resistance factor which is found when the particle travels with constant velocity under the influence of an external force. Statistical mechanics, however, holds that a particle in equilibrium with the surrounding molecules, does not experience a force dependent on its velocity, and hence no ordinary friction. The author derives a value for $\bar{\Delta}^2$, which, while not claiming great accuracy, leads, at least for the Brownian movement in a gas, to $\bar{\Delta}^2$ being proportional with $1/a^2$, where a represents the radius of the particle. Different investigators have performed measurements of $\bar{\Delta}^2$, however, almost always from the mutual differences of the times in which a particle travels a definite distance under the influence of an external force. With movement under an external force the distribution in space of the molecules of the medium is disturbed, and it moves for a part with the particle, so that the chance to a Brownian displacement upward or downward will no longer be symmetrical. The present author here describes an experimental investigation into the validity of the above equation, in which the displacement of a particle was measured while the gravity and the electric force were in equilibrium with each other. In order not to be disturbed by a small residual force the movement was observed in a horizontal instead of a vertical direction. The method of Millikan and Ehrenhaft was used, and full experimental details are given with illustrative diagram,

tables, and curves. The particles used were electrically sprayed mercury, ice oil (density 0·87), and potassium mercury iodide (density 2·56), this last being used to get a length of radius lying between that of the mercury and oil particles. For those particles $\bar{\Delta}^2$ is shown experimentally not to be proportional to $1/a^2$, whereas Einstein's formula, at least as far as the connection between $\bar{\Delta}^2$ and a is concerned, is confirmed. The behaviour of electrically sprayed mercury particles receives detailed attention and discussion.

H. H. Ho.

858. *New Equation of Continuity.* **F. G. Keyes.** (Nat. Acad. Sci., Proc. 3. pp. 323–330, May, 1917.)—This paper presents a pressure, volume, temperature relation which has been carefully compared with the greater part of the available experimental data during the past ten years. The equation, valid when only one type of molecule is present, is $p = RT/(v-\delta) - a/(v-l)^2$, where $\log \delta - \log \beta - a/v$, and β, α, a, and b are constants and R is the gas constant.

This equation is based on considerations resulting from the inferences regarding atomic structure, obtained since the discovery of the negative electron. The model atom consists of a positive central portion about which electrons are revolving. The negative electrons are assumed to possess a charge in the aggregate equal and opposite to the positive central charge. This model atom is essentially the atom discussed by Nicholson and by Bohr.

Estimates of the values of the constants are given for nitrogen and for argon. E. H. B.

859. *Einstein's Theory of Gravitation and Herglotz's Mechanics.* **G. Nordström.** (K. Akad. Amsterdam, Proc. 19. 6. pp. 884–891, 1917.)—Einstein has recently deduced his gravitation theory from Hamilton's Principle [Preuss. Akad. Wiss., p. 1111, 1916] by a method differing from those used by Lorentz and Hilbert. It is here shown that the mixed volume tensor appearing as momentum and energy in Einstein's equation 21 is obtained as tension-energy tensor when Herglotz's mechanics of deformable bodies is extended as required for Einstein's theory. Lorentz has solved the problem for incoherent masses [Abs. 720 (1917)], and the author finds that Lorentz's method may be extended to obtain the solution in the case of an arbitrary elastic body by a transformation to an arbitrary system of co-ordinates of Herglotz's formulæ, in which the $g^{\mu\nu}$'s have their normal values.

G. W. de T.

860. *Relativity and Gravitation.* **E. B. Wilson.** (Astrophys. J. 45. pp. 244–253, May, 1917.)—Notes are given of certain points in lectures on Einstein's work given to physical students at Harvard, dealing with generalised co-ordinates, relativity, and gravitation. C. P. B.

861. *On Jacobi's Integral in the Restricted Problem of Three Bodies.* **T. Matukuma.** (Math. Phys. Soc., Tōkyo, Proc. 9. pp. 2–8, Jan., 1917.—Mathematical.

862. *Mercury Jets.* **S. W. J. Smith** and **H. Moss.** (Roy. Soc., Proc. 93. pp. 373–393, July 2, 1917.)—Describes a number of experiments on jets of mercury and other liquids. In the first set of experiments mercury jets of different diameters and surface tensions, falling into aqueous solutions, were used. The density and viscosity of the jet-fluid remained unchanged. It was found that two critical velocities occur, and for any pair of jets corresponding critical velocities are connected by the relation $v_1 : v_2 = \sqrt{(\sigma_1/d_1)} : \sqrt{(\sigma_2/d_2)}$,

where σ and d denote respectively the surface tension and diameter of the jet. The view is taken that the critical velocities have their origin in certain known peculiarities of fluid motion which, the authors suppose, cause comparatively sudden changes, at particular velocities, in the initial amplitude of the disturbance under which the jet breaks down. It has then been found that the ratio of the initial to the final (disintegrating) disturbance is the same, at corresponding critical points, for all the jets examined. The changes occurring at such critical points are thus always of exactly the same nature. Change of diameter or of surface tension merely alters the velocity of efflux at which each change occurs. Further, these regularities are not confined to the critical points. The sequence of changes of initial amplitude between these points is again always the same. In consequence, for any pair of jets, the initial disturbance is the same fraction of the final disturbance for any pair of velocities whose ratio is $\sqrt{(\sigma_1/d_1)} : \sqrt{(\sigma_2/d_2)}$, and, with these velocities, the jet lengths are in the ratio $l_1 : l_2 = d_1/d_2$.

The second set of experiments may be described as forming a link between the first set and the well-known experiments of Savart. Nozzles of the same kind as before were used, but the jet liquid was now surrounded by air. Using mercury and water, the relation $v_c a(\sigma/\rho d)^{1/2}$ was tested and found to be nearly true. The mercury jet had similar properties to those previously studied, and, as before, between the critical velocities dl/dv increased as v increased. Water behaves differently. Jets of diams. between 0·18 and 0·5 mm. were examined, and the following results were obtained :— Between the critical points each lv curve forms part of a straight line passing through the origin. Hence for each jet $dl/dv = l/v = t =$ constant, where t is the time of disintegration, *i.e.* the time taken by each element of the liquid to pass from the top to the bottom of the jet. The value of this constant increases with the diam. of the jet, but when l/d is plotted against $v\sqrt{(\rho d/\sigma)}$ the observations for all the jets fall upon the same straight line. From this it follows that $l/d \div v\sqrt{(\rho d/\sigma)} = l/v \,.\, \sqrt{(\sigma/\rho d^3)} = t\sqrt{(\sigma/\rho d^3)}$ has the same value for all the jets. The cause of disintegration is taken to be the disturbance which originates at the orifice, and Rayleigh's theory leads to the result that the rate of growth of this disturbance is given by $ae^{k\tau\sqrt{(\sigma/\rho d^3)}}$, where a is the initial amplitude, k is a constant, and τ is the time elapsed since the disturbance began. If this theory is applicable, the ratio of the initial to the final amplitude for each jet is given by $e^{-kt\sqrt{(\sigma/\rho d^3)}}$, and is therefore the same for all, since it has been found that $t\sqrt{(\sigma/\rho d^3)}$ is constant. The initial amplitude is, apparently, a constant fraction of the diam. of the jet. As Rayleigh has pointed out, some of Savart's results suggest a simple relation of this kind, while others suggest that the relation is more complicated. The present experiments indicate that if narrower jets had been used by Savart, the simple relation would have sufficed to define their behaviour. The critical velocities, if they exist, obey a different law when, as in Savart's experiments, the liquid escapes through a sharp-edged hole in a horizontal plate. The critical velocities observed in the present experiments owe their existence to the shape of the nozzle used, which favours the generation of eddies or vortices. A. W.

863. *Observations of Evaporation.* **B. C. Kadel** and **C. Abbe.** (Monthly Weather Rev. 44. pp. 674–677, Dec., 1916.)—Evaporimeters of a standard pattern for measuring the daily depth of water evaporated from a free water surface, have been installed at 24 stations of the U.S. Weather Bureau during the past two years. Observations of max. and minimum air temperature,

rainfall, and velocity of the wind just above the rim of the evaporimeter are also made daily at each station. The evaporimeter consists of a circular pan 4 ft. in diam. and 10 in. deep. It is kept filled with water to within 2 in. from the rim, and is built upon a wooden base in such a way that its rim is not less than 16 in. above ground-level. Inside the pan, and about a foot from its northern side, stands a still-well, in which the level is accurately determined by means of a hook-gauge. The still-well consists essentially of a brass tube 8 in. high and $3\frac{1}{2}$ in. outside diam. fixed to a base which can be levelled by three levelling screws bearing upon the bottom of the pan. The tube is connected to the water in the pan by a small brass pipe. The hook-gauge rests on the upper end of the still-well and consists of a hook suspended from a graduated scale which is moved up and down relative to the still-well by a micrometer screw. The method of observation consists in lowering the hook by means of the micrometer screw until its point is submerged, and then raising it cautiously until the point just breaks through the water-surface. The reading to the thousandth of an inch is then taken from the graduated scale and the micrometer screw.

Observations are made daily at a fixed hour, usually about 7 a.m., and the amount of evaporation for the previous 24 hours is taken to be the difference between yesterday's and to-day's hook-gauge readings *plus* the rainfall measured at the time of observation. The observations obtained at the stations will be published officially by the Weather Bureau. R. C.

864. *Some Nuclei of Cloudy Condensation.* III. **J. Aitken.** (Roy. Soc. Edinburgh, Proc. 37. pp. 215–245, 1916–1917.)—The nuclei of the atmosphere, formerly termed by the author dust particles, but now recognised to be very much smaller than the ordinary particles of dust raised in a wind, have been the subject of a good deal of investigation. Of late it has been definitely stated by some workers that these nuclei are mere aggregations of ions and not of the nature of dust particles. The present investigation was carried out to test this theory, and incidentally many subsidiary experiments were made. A new piece of apparatus was devised in which the saturated sample of air in a test flask could readily and almost instantaneously be expanded, and thus given any degree of supersaturation within reasonable limits. The "size" of the nuclei is measured by the degree of supersaturation required to produce condensation upon them, a 2 % expansion of the air in the test flask being sufficient to cause condensation upon the larger nuclei, while higher degrees of supersaturation are required for the smaller ones, until a 25 % expansion is required to produce condensation on individual ions. The "size" of the nuclei measured in this way does not necessarily mean the relative dimensions, though probably not far from it.

With the aid of the new apparatus, tests were made on the effect of heat acting on different materials as a nucleus producer. It was found that when any material became sufficiently heated to cause an alteration in the flame in contact with it then nuclei were produced. This held in the case of glass, porcelain, alundum, and also with copper and other metals. This production of nuclei from heated surfaces affords some explanation of the wearing away of bars of grates and linings of furnaces in cases where these are not exposed to friction. Some metals, as magnesium, were found to have the power of producing nuclei when cold, while others, as aluminium, had little effect. Experiments with ordinary air and with the pure air found in the neighbourhood of Loch Awe both showed that whereas large nuclei were present, small nuclei requiring more than a 6 % expansion to produce condensation

were generally absent. This did not support the theory that nuclei are aggregations of ions, since in this case nuclei of all sizes from that of a single ion upwards would be expected. Some tests were made with air ionised by means of radium salts, but even after long intervals extending up to a day no tendency was observed for the ions to combine and produce large nuclei. It is therefore considered as proved that the "large ions of the atmosphere" are in reality nuclei to which an ion has become attached and given up its charge. The paper contains much detail information which cannot be summarised in an abstract. J. S. Di.

865. *Types of Anticyclones of the United States and their Average Movements.* **E. H. Bowie** and **R. H. Weightman.** (Monthly Weather Rev. Suppt. No. 4. pp. 3–25, 1917.)—The present paper deals with the anticyclones of the United States along the same general lines followed in a previous paper [Abs. 535 (1915)]. Beyond a statement of published views concerning the forces that originate, maintain, and propel anticyclones across the United States at a rate of speed that is little less than that of cyclones, no attempt is made to deal at length with theories concerning their origin, etc. It is largely statistical, with, however, brief descriptions of the types of anticyclones, their courses, and the resulting weather and temperature conditions. L. H. W.

866. *Observations of the Neutral Points of Atmospheric Polarisation from Great Heights.* **A. Wigand.** (Phys. Zeits. 18. pp. 237–240, June 1, 1917.)—Observations of the positions of the neutral points of Arago and Babinet were made in the early morning of 3rd May, 1914, from a free balloon. The balloon started from Bitterfeld at 3.14 a.m., Middle European time, and observations of polarisation were obtained from 3.59 to 5.35 a.m. during which time the balloon rose from 3100 to 5850 m. The angular distances of Arago's point from the antisolar point are plotted against the elevation of the sun and compared with corresponding observations made on the earth's surface, showing that the elevation from which the observations were made did not affect the position of the neutral point. Similarly the distances of Babinet's point from the sun are shown to be unaffected by variation in height of the point of observation, within the limits of accuracy of observation.

The conclusion provisionally drawn from the few observations available is that the phenomena of polarisation do not belong exclusively to the lower layers. As they show no appreciable change in the first 6000 m., they are possibly to be considered as a property of the stratosphere. R. C.

867. *Influence of Intense and Prolonged Bombardment on Rainfall.* **H. Deslandres.** (Comptes Rendus, 164. pp. 613–615, April 23, 1917.)—The question whether bombardment can produce rain is still an open one. Certain possible physical processes which might be adduced in support of the hypothesis are set out, and the conclusion is drawn that the influence of artillery is admissible, but that in general the quantity of rain produced by bombardment is smaller than that due to processes which determine ordinary changes of weather. The physical processes referred to depend upon condensation by ionised air which is produced in various ways as a result of bombardment.

In a note on the above, **G. Lemoine** (Ibid. p. 615) expresses the opinion that any rain produced by explosions could only be light and local. Heavy downpours could not be accounted for in this manner.

In a later note, **Sebert** (Ibid. pp. 663–669, April 30, 1917) remarks that whereas Deslandres has dealt with the immediate effects of explosions, he himself considers that there may be effects at a considerable distance from the area of bombardment, and cites the case of Le Maout, who, during the Crimean War, gave dates of the most important battles from the meteorological effects observed in France, in advance of direct information from the Crimea.

[*Note by abstractor.*—In order that ions may be effective in producing condensation, C. T. R. Wilson has shown that a "fourfold" degree of supersaturation is required for the negative ions, and a considerably higher degree for the positive ions. Aitken and others have, however, shown that supersaturation is impossible so long as there are any particles of dust, or of certain gaseous substances in the air. Aitken has further shown that dust is present in appreciable quantity in every sample of air which he examined. Some of these samples were taken from the tops of high mountains far from towns. Consequently, we cannot suppose that ions are the immediate cause of any condensation produced by bombardment. It is impossible to ascertain definitely whether bombardment can produce rain or not, because we cannot determine in any specific case what the rainfall would have been in the absence of bombardment. There is a very widespread notion that bombardment may exercise an influence on the weather, but no rational account of the complete process has been put forward. The statistical evidence which is available does not support the proposition.] R. C.

868. *The Arithmetic Mean and the "Middle" Value of Certain Meteorological Observations.* **L. Becker.** (Roy. Soc. Edinburgh, Proc. 37. pp. 210–214, 1916–1917.)—The max. daily temperatures observed at Glasgow Observatory over a period of 48 years have been taken, and the distribution of these about their "middle" value calculated for each day of the year. It is found that the distribution is not normal, but that from March to Oct. the extremes of high temperature lie much further from the middle value than the extremes of low temperature, the scattering in Sept. extending 10° F. further on the positive side than on the negative. In the winter, on the contrary, the scattering extends 8° further on the negative side than on the positive. When all days of the year are taken together this lack of symmetry disappears. The difference "Middle temperature — Mean temperature" is found to vary from +0·5° F. in Feb. to —0·75° in Aug. J. S. Di.

869. *Alternate Deposition of "Rauhreif" and "Rauheis."* **W. R. Blair.** (Monthly Weather Rev. 45. p. 19, Jan., 1917.)—A photograph (reproduced in the paper) of frozen precipitation on a twig shows that alternate layers of snow crystals and transparent ice were built up on the windward side of the twig during a night of fog when the temperature was below freezing. A wind of 17 miles/hr. was blowing at the time. The author suggests that variations in the size of the water drops composing the fog were the cause of these alternating layers. The larger drops broke up on coming in contact with the twig and spread out before freezing into a transparent ice layer, while the smaller drops crystallised immediately and adhered in the form of white rime. J. S. Di.

870. *Internal Seiches and Undulation of the Discontinuous Layers in Lake Shikotsu.* (Tôhoku Univ., Sci. Reports, 6. pp. 31–40, June, 1917.)—The party of summer tourists who are responsible for this paper remark that since the

ordinary and internal seiches in certain of the Japanese lakes have been repeatedly reported on by Honda and others, another case where they occur may seem superfluous. They claim, however, that more light has been thrown on the nature of the internal seiches by the present example. The special feature noted has been the existence of another kind of temperature-change whose appearance is due to the slow variation of the mean depth of the discontinuous layer, in addition to the temperature-change due to ordinary internal seiches. A very detailed description is given, illustrated by numerous diagrams and curves. H. H. Ho.

871. *The Glacial-control Theory of Coral Reefs.* **R. A. Daly.** (Am. Acad., Proc. 51. pp. 157–251, Nov., 1915.)—The narrowness of the coral reefs about the Hawaiian islands suggested that they were geologically very young, and the discovery that a considerable glacier had left its traces on Mauna Kea directly indicated a possible connection between the youthfulness of the reefs and the former climate of the archipelago. From this study the author has evolved his glacial-control theory which emphasises the Pleistocene as one period of inhibited coral growth, the bulk of the erosion which has affected the oceanic plateaus being clearly pre-Glacial in date. The present paper commences with an outline of the theory together with a review of previous work bearing on the subject. Pleistocene temperatures of the Tropical Ocean are considered together with the lowering of sea-level by Pleistocene glaciation, the consequent diminished volume of ocean water, and the gravitative influence of ice-caps. The conclusion is drawn that, at the time of max. glaciation, the tropical seas probably had an average level which was 60 m. to 70 m. lower than at the present time. Islands and continental shores during the Glacial period are next dealt with, this section including the character of the shore rocks and the heights of the Pleistocene islands. It appears that most oceanic islands, at the time of max. glaciation, were (*a*) low, with the height of the land above sea after the shift of sea-level ranging between zero and a value little greater than the vertical (downward) shift of sea-level; and (*b*) composed of generally weak material—detrital embankments surrounding or covering an eroded central mass of decayed volcanic rock, which itself was likely to be weak also because of the presence of ash-beds. The encircling talus embankment carried veneers of coral-reef material of varying strength. The new coastal plains along the edges of continents and greater islands were all low and mostly composed of very weak materials. It is probable that these gigantic embankments were only partly veneered with massive material and such comparatively strong rock was in danger of undermining and rapid destruction as soon as the sea-level fell 45 m. or more, because of glaciation in higher latitudes. On the other hand, the high volcanic islands were young and any wave-benching in their strong massive lava would be much slower than in that of the older islands or of the continental shelves.

The next section deals with the origin of the coral-reef platforms and includes the size of the actual platforms, the pre-Glacial history of volcanic islands, the duration of Pleistocene abrasion, the rate of Pleistocene wave-benching, the depth of the Pleistocene benches below the present sea-level, the depths of lagoons and of coastal shelves in stable areas, and the testimony of islands uplifted in post-Pleocene time. The latter section is illustrated by numerous tables and diagrams. The origin of the existing reefs then receives detailed attention, including the consideration of the colonisation of the platforms, the upward growth of the reefs, special development of reefs at the edges of platforms, drowned atolls and other banks, and the volumes of the existing reefs.

Here the youth of the Hawaiian reefs receives an explanation on the glacial-control theory. The objections to the latter theory are examined with care under the sub-sections of Glacial lowering of sea-level within the tropics, Restriction of reef corals by Pleistocene cold, General crustal stability in the coral-sea areas, Sea-cut platforms and drowned valleys outside the coral seas, Drowned valleys of the coral islands, Pleistocene cliffing of oceanic islands, and Biology of oceanic islands. The difficulties of the subsidence theory next receive attention, the sub-sections being :—Alternative subsidence theories, Uniformity of the assumed subsidence, Alleged proofs of current subsidence, Permanence of the Pacific basin, Small maximum depth of lagoons, Flatness of lagoon floors with comparison of depths in lagoons and on banks, Psychological influence of classic diagrams, and the Test by boring through reefs. Numerous diagrams are given in illustration. This latest theory by no means excludes belief in the importance of pre-Glacial marine erosion in preparing the reef platforms. The existing reef-coral species appear to have been evolved during the Tertiary period.

The Glacial-control theory has been formulated as the first systemative attempt to show where and when the uniformitarian principle as applied to the life conditions of reef-building species breaks down. H. H. Ho.

872. *Determination of Solar Motion by Least Squares.* **E. S. Manson, Jr.** (Astron. J. 30. pp. 149–154, June 4, 1917.)—A modification of the ordinary method of analysis by the formation of normal equations, but without making use of the law of error, is outlined, and illustrated by the problem of obtaining the direction and velocity of the sun with regard to the geometrical centre of mass of the system of the stars. Comparisons are made of the methods of Bravais, Campbell, and Airy. C. P. B.

873. *Minute Structure of Solar Atmosphere.* **G. E. Hale** and **F. Ellerman.** (Nat. Acad. Sci., Proc. 2. pp. 102–108, Feb., 1916.)—A short summary is given of the result of an extensive investigation of spectroheliograms showing the structure of the solar atmosphere at various levels in comparison with that of the low-lying photosphere and sun-spots. For the photosphere Langley's "rice grains" and "granules" are still the best standards for denoting the minute structure, the granules being about 0·3″ in diameter (say 130 miles). Photographs taken with the spectroheliograph in calcium light can be made to show details at different levels according to the slit setting. The smallest calcium flocculi observed are less than 1·0″ in diameter. In the case of the highest levels shown by the dark hydrogen flocculi in Hα light, the smallest flocculi are about 2″ in diameter. This seems to support the view that the photosphere and gaseous atmosphere above it are formed of columns of hot gases, rising by convection from the interior of the sun. To illustrate these differences of level a stereoscopic picture is given of a dark hydrogen flocculus floating over the region of a large spot group on 1915 Aug. 7 ; the vortex action of the spots is also well shown by the bending of the hydrogen flocculus near the spot umbræ. It is concluded that the minute structure of the quiescent solar atmosphere resembles that of the photosphere. In disturbed regions, the small granular regions are replaced by slender filaments, lying side by side, resembling the structure of penumbræ of sun-spots. C. P. B.

874. *General Form of the Lunar Surface.* **P. Puiseux** and **B. Jekhowsky.** (Comptes Rendus, 164. pp. 562–567, April 10, 1917.)—Photographs of the moon on a large scale have been impressed with a reseau, and the radius measured at intervals of 15° round the limb. These measures, taken at different aspects

and with varying librations, serve to give determinations of the general contour of the moon's limb as seen from the earth. Several positions of excess and defect are noted, but no systematic inequality greater than 1500 m. appears to be present. In the case of the earth, the polar flattening and tetrahedric deformation give rise to much greater differences. C. P. B.

875. *Motion of Perihelion of Mercury.* **L. Silberstein.** (Roy. Astron. Soc., M.N. 77. pp. 503–510, April, 1917.)—From the early work of Le Verrier in 1845 it has been known that the motion of the perihelion of Mercury was in excess of that accounted for by the perturbations due to the other planets of the solar system, and recent determinations give the excess of motion as 43″ per century. This amount is closely predicted by the formulæ of Gerber [Zeitschr. Math. Phys. 43. pp. 93–104 (1898)] and Einstein [Abs. 853 (1916)]. Formulæ are developed in the present article from what the author styles the "old" theory of relativity, given by Einstein in 1905 and elaborated by Minkowski in 1907, and terms introduced to evaluate the planetary secular excess. C. P. B.

876. *Orbit and Probable Size of a Faint Asteroid.* **S. B. Nicholson** and **H. Shapley** (Astron. J. 30. pp. 127–128, May 5, 1917.)—Definitive elements for the orbit of a small asteroid are obtained from photographs taken at Mt. Wilson during Sept. and Oct. 1916. Inferences are made as to albedo and colour index which may have to be revised, but on the assumptions made (albedo equal to Mars and the brighter asteroids) the magnitude observed corresponds to a diameter of only 2 or 3 miles. C. P. B.

877. *Light-changes of β Lyræ.* **P. Guthnick** and **R. Prager.** (Preuss. Akad. Wiss. Berlin, Ber. 12. pp. 222–242, 1917.)—Observations have been continued with the photoelectric photometer at Berlin-Babelsburg, dealing with the variable β Lyræ, for which the deduced light-curve is given. [See Abs. 303 (1916).] C. P. B.

878. *Orbit of Krueger,* 60. **H. N. Russell.** (Astron. J. 30. pp. 131–136, May 8, 1917.)—Generally orbit determinations of visual binaries are based on the relation that the observed positions of the companion must lie on an ellipse. Comstock pointed out many years ago that the time is known more accurately than the other data of observation, and the present determination is made to illustrate what advantages may be gained by taking full account of the dynamical relations between the coordinates and the time. The system is noteworthy on account of its large proper motion, large parallax, and rapid orbital motion. C. P. B.

879. *Orbit of ε Equulei.* **H. N. Russell.** (Astron. J. 30. pp. 123–126, May 5, 1917.)—This system consists of a close and nearly equal pair (5·8 and 6·3 mag.), and is a good example of a binary whose orbit is turned almost edgewise towards the earth. The observations available from 1837 are discussed, and a set of final elements given. An ephemeris is added for future observations up to 1927. The period is about 97·4 years. C. P. B.

880. *Parallax of Barnard's Large-Proper-Motion Star.* **S. A. Mitchell.** (Astron. J. 30. pp. 126–127, May 5, 1917.)—From measurements on seven photographs taken with the 26-in. McCormick refractor of the University of Virginia the parallax of this remarkable star is found to be $\pi = +0{\cdot}47''$. This result is in excellent agreement with that obtained by Schlesinger [Abs. 476, 881 (1917)]. C. P. B.

881. *Parallax of Barnard's Large-Proper-Motion Star.* **F. Schlesinger.** (Brit. Astron. Assoc., J. April, 1917. Nature, 99. p. 293, June 7, 1917. Abstract.)—The parallax found for this interesting star, whose proper motion is unusually large, is 0·52″. This star thus becomes second to α Centauri with respect to distance from the solar system. C. P. B.

882. *Origin of Star Clusters.* **E. Belot.** (Comptes Rendus, 167. pp. 513–515, March 26, 1917.)—The possibility of star clusters being produced by some such vortical disturbance as appears in the case of the solar system and the spiral nebulæ is discussed, and several formulæ are given which appear to support the idea respecting the distribution of the component stars and their arrangement. C. P. B.

883. *Radiation of the Stars.* **A. S. Eddington.** (Nature, 99. pp. 308–310, June 14, 1917.)—An attempt is made to determine analytically the conditions of stellar radiation on the assumption that the internal state may be considered similar to that of a perfect gas. Assuming a molecular weight of 54, and a specific heat ratio of 4/3, relations of temperature and absorption are found which are manifestly untenable. To avoid the difficulty, the effect of the pressure of radiation is invoked, and this brings the effective temperatures for stars of different spectral types more within the limits of possibility, the conclusion being stated that the effective temperature of a giant star is proportional to the sixth root of the density. The total radiation will depend only on the mass and not on the density or stage of evolution. With a smaller molecular weight than 54 the importance of radiation-pressure is reduced. C. P. B.

884. *Secular Changes in Stellar Proper Motions.* **F. Schlesinger.** (Astron. J. 30. pp. 137–138, May 8, 1917.)—Several stars have been discovered in recent years having such large parallaxes and proper motions that it may be possible to obtain reliable values of the secular changes in proper motion, parallax and radial velocity caused by the star's movements in space. The necessary formulæ required for the reduction of such observations are briefly outlined. C. P. B.

885. *Parallax of Barnard's Large-Proper-Motion Star.* **O. J. Lee.** (Astron. J. 30. p. 138, May 8, 1917.)—From nine photographs taken with the 40-in. Yerkes refractor during 1916–1917 the preliminary value for the parallax is given as $\pi = 0{\cdot}52''$. C. P. B.

886. *Theoretical Duration of the Green Ray.* **G. Guglielmo.** (N. Cimento, 7. pp. 157–165, Oct., 1916.)—Mathematical discussion of the duration of the green ray as affected by the latitude of the place of observation and the solar declination. For the effect of certain accidental causes see Ibid. 12. p. 76, 1916. A. D.

887. *Eight Variable Stellar Spectra.* **H. Shapley.** (Nat. Acad. Sci., Proc. 2. pp. 208–209, April, 1916.)—To test the general features of Cepheid variation spectrograms of representative variables of this class have been made with a 10-in. portrait lens and objective prism at Mt. Wilson. The periods range from 9 hours to 27 days. A table is given showing, for eleven stars, the definite change of spectrum from maximum to minimum; the changes, moreover, are along the lines of the evolutionary scheme of the Harvard classification. C. P. B.

888. *Colour of Standard Polar Stars.* **F. H. Seares.** (Nat. Acad. Sci., Proc. 3. pp. 29–33, Jan., 1917.)—A method has been developed for measuring star colours, depending on the ratio of the exposure times necessary for blue and yellow light respectively to produce images of the same size [Abs. 470 (1917)]. Results have been obtained for 80 of the North Polar standards from photographs taken with the 60-in. reflector at Mt. Wilson. Precautions have been taken to use plates of the same emulsion for all comparisons of the series. It is thus found that the colours of the polar standards are now known with about the same precision as the magnitude scales. An interesting result is the confirmation of a previous conclusion that there are no faint stars in this region having negative or small positive colour-indices. C. P. B.

889. *Proper Motions, Radial Motions and Magnitudes of B and A Stars.* **C. D. Perrine.** (Nat. Acad. Sci., Proc. 2. pp. 289–292, May, 1916.)—It has already been shown that whereas there is a decrease of proper motion with decreasing brightness in the B stars, the radial velocities show an increase, and this feature is still more pronounced in the A stars. Tables are given showing relations of proper motion, radial velocity, and magnitude for classes B and A, from which it is shown that the radial velocities appear to decrease, in general, with increasing proper motion. The velocity distributions of classes B–B5 and A differ from the distributions for F, G, K, and M stars, as given by Kapteyn and Adams, and appear to be more in accord with Maxwell's law. There are indications of a small abrupt change in the velocities of both classes in the smallest proper motions [Abs. 1012 (1915)]. C. P. B.

890. *Asymmetry in Proper Motions and Radial Motions of B Stars.* **C. D. Perrine.** (Nat. Acad. Sci., Proc. 2. pp. 292–294, May, 1916.)—From an analysis of the proper motions of B stars a systematic difference is shown between the values in the region about 0 h. and that opposite, and it appears that these regions are almost at right angles to the direction of solar motion. The solar velocities derived from northern B stars are smaller than those from southern B stars. These results lead to the suggestion that there may be a general motion of rotation of the system of stars in a retrograde direction about an axis perpendicular to the Milky Way. C. P. B.

891. *Orbit of ζ Hercules.* **G. C. Comstock.** (Astron. J. 30. pp. 139–148, May 24, 1917.)—This binary star has now been well observed over more than two revolutions of its orbit, but the adopted elements are not yet in agreement with the observed places, indicating that some undetected factor is still outstanding. To explain these discrepancies Lohse has suggested that there may be systematic errors of observation, and Lewis thinks there may have been substantial changes in the orbit itself, *i.e.*, a progressive increase in the major axis and eccentricity, and an oscillating value of the periodic time. In the present note all the available material from 1826 to 1916 is investigated from these points of view, and a table is given showing the resulting corrections, with a paragraph describing the peculiarities of individual observers. From the combined corrections a new set of definitive elements is given, taking the period as 34·46 years. These show that with undisturbed motion the agreement with observation would be fairly satisfactory. Small irregularities are found which may be well represented during the three-quarters of a century of observation as the effect of an invisible companion having a periodic time of 18 years and an amplitude less than 0·1″. C. P. B.

892. *Mean Parallax of Stars of Different Magnitudes.* **F. W. Dyson** and **W. G. Thackeray.** (Roy. Astron. Soc., M.N. 77. pp. 7–16, Nov., 1916.)—

Proper motions have been determined for nearly 12,000 stars in the region $\delta = +24°$ to $+32°$, by comparison of Greenwich observations 1906–1915 with the A.G.C. catalogues and the earlier observations of Bessel and Lalande. The difference of epoch is generally 30–40 years; the number of stars compared with Bessel is about 7000, with an interval of about 80 years; with Lalande about 4500 stars with an interval of approximately 110 years. The discussion of the results is given with relation to magnitude, a formula connecting the mean parallax and magnitude being derived, and a table shows the mean parallaxes of stars from 5·0 to 10·5 magnitude, with comparisons of the very similar results obtained by Kapteyn for the same groups. C. P. B.

893. *Radiative Equilibrium of the Stars.* **A. S. Eddington.** (Roy. Astron. Soc., M.N. 77. pp. 16–35, Nov., 1916.)—The theory of radiative equilibrium of a star's atmosphere outlined by Schwarzschild in 1906 is applied to the consideration of the internal physical conditions by suitable modifications of the formulæ. Taking the case of a giant star of low density the calculations on the idea of a perfect gas lead to a temperature gradient so great that the outflow of heat would be enormously greater than observation indicates. This difficulty is avoided by assuming that the radiation-pressure may neutralise the gravitational effect at interior points, and by this means results are obtained which correspond roughly with observation. C. P. B.

894. *Distribution of Stars in Twelve Globular Clusters.* **F. G. Pease** and **H. Shapley.** (Mt. Wilson Solar Obs., Contrib. No. 129. Astrophys. J. 45. pp. 225–243, May, 1917.)—Counts have been made of more than half a million star images on a series of plates taken at the Mt. Wilson Solar Observatory with the 60-in. reflector, and the discussion of the results has been made with the view of detecting the presence of galactic planes, indicated by elliptic distribution of the individual stars. Of the nine clusters for which definite counts are available, five show elliptical form, three appear sensibly circular, and one may be peculiar. Previous failure to detect these ellipticities is ascribed to the influence of the brighter stars present in the clusters. The axes of symmetry do not appear until the arrangement of several thousand stars is analysed; then the ellipticity appears at all distances from the centre, and for all magnitudes, after the giant red stars are excluded. C. P. B.

895. *Systematic Motion among Stars of Helium Type.* **B. Boss.** (Nat. Acad. Sci., Proc. 2. pp. 214–216, April, 1916.)—The zone of sky containing all the helium stars has been mapped into twelve arbitrary divisions, and the motions of the stars in each area treated statistically, giving curves showing the residual preferential motions in the sky. There appears to be a strong tendency for these stars to move in their own plane, but there are numerous instances where stars tend to spread in other directions. There seems to be nothing systematic in the motions directed away from the plane of the stars. C. P. B.

896. *Variability of Uranus.* **L. Campbell.** (Harvard Coll. Obs., Circular No. 200. Observatory, No. 514. p. 238, June. 1917.)—Photometric observations of the planet Uranus show that its light varies by about 0·15 magnitude in a period of 0·451 day. This period agrees with that of the planet's rotation determined spectroscopically by Lowell and Slipher, and it is concluded that the variation is due to unequal brightness of different portions of the surface. C. P. B.

897. *Possible Origin for some Spiral Nebulæ.* **G. F. Becker.** (Nat. Acad. Sci., Proc. 2. pp. 1–8, Jan., 1916.)—The forms produced by rotation under known gravitational laws of a mass of nebulous material of assumed form are computed, the resulting scheme being a double-armed spiral remarkably similar to many known nebulæ. C. P. B.

898. *Absorption of Light in Space.* **H. Shapley.** (Nat. Acad. Sci., Proc. 2. pp. 12–15, Jan., 1916, and 3. pp. 25–29, Jan., 1917.)—Continuing his work on the studies of magnitudes in star clusters [Abs. 736 and 755 (1917)], a description is given of the preliminary investigation of the amount of absorption of light in space. If this is due to molecular scattering it will vary as the fourth power of the wave-length, and thus the effect being greater for blue than for red radiations, the method of colour indices gives a direct indication. In order to eliminate the uncertainty of a possible distance effect in taking isolated stars, the stars in the cluster M 13 are investigated, and from the fact that many negative values of the colour indices are found, it is concluded that no measurable selective absorption in space is existent. C. P. B.

899. *Sequence of Spectral Types in Stellar Evolution.* **H. Shapley.** (Nat. Acad. Sci., Proc. 2. pp. 15–18, Jan., 1916.)—Taking colour index as an indication of spectral type, the relations of the various stars measured in the photographs of the star cluster M 13 at Mt. Wilson are tabulated with respect to magnitude and type. The conclusion is that giant second-type stars are present in large numbers in the globular clusters, and that on the average among the four or five brightest magnitudes the brighter the star the redder the colour. The opposite is the case for the dwarf stars, where it is thought the cooling stars are growing redder, fainter, and smaller with age. C. P. B.

900. *Systematic Errors in Photographic Distances of Double Stars.* **F. A. Bellamy.** (Roy. Astron. Soc., M.N. 77. pp. 521–525, April, 1917.)—In connection with the possible mutual effect of photographic images [Abs. 941 (1917)] 436 double stars have been examined in the Oxford series, and from comparisons with the visual observations made by Burnham it appears that there are systematic errors in photographic measures of close pairs. C. P. B.

901. *Determination of Constant of Aberration.* **S. S. Hough.** (Roy. Astron. Soc., M.N. 77. pp. 484–502, April, 1917.)—During 1911 the new reversible transit-circle of the Cape Observatory was devoted exclusively to the observation of a series of close circumpolar stars, and a provisional discussion [Cape Annals. 12. part 3] dealt with the utilisation of the material for the determination of the constant of aberration. No special provision had been made, however, to secure the observations under the most favourable conditions for yielding large aberration factors. In the present note it is suggested how the programme of observations may best be modified with a view to repetition, and the observations are treated more rigorously in the derivation of the aberration constant, which is given as 20·44″, as the mean of four determinations from different arguments. C. P. B.

902. *Proper Motions with Blink-microscope.* **R. Innes.** (Union Obs. S. Africa, Circ. No. 37. pp. 288–300, Feb. 28, 1917.)—Examination of 23 pairs of plates from the Melbourne Observatory, with time intervals varying from 15 to 23 years, has furnished a considerable number of large proper motions. These are tabulated in order of R.A. with detailed notes of the plate measurements. The latter part of the paper deals similarly with three pairs of plates

from the Cape Observatory, with time intervals from 21 to 33 years. One of these regions has previously been examined by Kapteyn in the ordinary way, and comparisons are made of the results given by the two methods. C. P. B.

903. *Variable Stars near Corona Australe.* **R. Innes.** (Union Obs. S. Africa, Circ. No. 37. p. 300, Feb. 28, 1917.)—Examination of plates of the region of R. Corona Australe taken on July 19, 1916, and July 23, 1914, resulted in the detection of several new variables, and the work being continued, lists are given of 169 new variable stars found by the blink-microscope method. C. P. B.

904. *Refraction at Mount Hamilton.* **R. H. Tucker.** (Lick Observatory, Bull. 9 [No. 292], pp. 56–63, 1917.)—Observations have been continued on the diurnal variation of refraction as shown by determinations with the meridian circle throughout the time that stars are visible during the day. The difference in refraction between night and day appears to be in no sense a seasonal one. They do not seem to be affected by the range of recorded temperature, nor by the changes of temperature during the periods of observation. A table is given showing the resulting corrections to the Pulkowa refractions which will be adopted in future at Lick. These indicate a zero correction at one hour preceding sunset, or one hour following sunrise. C. P. B.

905. *Radial Velocities of Eleven Southern Variables.* **G. F. Paddock.** (Lick Observatory, Bull. 9 [No. 294]. pp. 68–73, 1917.)—Observations are recorded of the radial velocity of eleven variables from spectrograms taken at the D. O. Mills Observatory at Santiago, Chile, in 1909, using a single-prism spectrograph on the 37-in. reflector. The dispersion of the spectra is 41 Å per mm. at H_γ. Five of the stars are Cepheid variables; they exhibit the characteristic features of the class—considerable eccentricity; similar order of amplitude of velocity, from 20–40 km./sec.; greatest negative velocity occurring a few tenths of a day later than maximum light; close correspondence between times of max. velocity and minimum light. Details of the spectra are given for each star. C. P. B.

906. *Method for determining Colours of Stars.* **F. H. Seares.** (Nat. Acad. Sci., Proc. 2. pp. 521–525, Sept., 1916.)—To obviate various drawbacks in the methods hitherto adopted for the determination of colours of stars, a simplified scheme has been developed involving the ratio of exposure-times necessary to produce photographic and photovisual, or blue and yellow, images of the same size. For convenience and accuracy the images should be on the same plate. In practice there will be for each star one yellow image and a series of three or four blue images, with the exposure-times for the latter increasing in geometrical progression. The diameters of the blue images are then plotted against the logarithms of the exposures, and from the nearly linear curve thus derived can be read the necessary exposure-time for a blue image of the same size as the yellow image. The ratio of this to that given for the yellow image furnishes the colour-index. Various precautions are outlined and a table is given showing the results of a preliminary examination of 10 stars. [Abs. 309 (1916); 470 (1917).] C. P. B.

907. *Relative Motions in Planetary Nebulæ.* **W. W. Campbell** and **J. H. Moore.** (Nat. Acad. Sci., Proc. 2. pp. 566–569, Oct., 1916.)—In a former paper the authors have described the rotation phenomena determined

by spectrographic methods in the planetary nebula N.G.C. 7009 [Abs. 652 (1916)]. The work has since been extended to 33 other bright planetary nebulæ. Of these 16 give definite evidence of relative motion, and it is suspected in 5 others. For 12 no indications of motion were detected. The ease of observation depends somewhat on the size of the nebular image, as in the smaller stellar types it is difficult to set the slit on the position of max. motion. With one or two exceptions the nebulæ in which relative motion has been observed are elliptic in form. The suggestion is that these bodies may be ellipsoidal shells in rotation about their minor axes. C. P. B.

908. *Spectroscopic Method of determining Stellar Parallaxes.* **W. S. Adams.** (Nat. Acad. Sci., Proc. 2. pp. 147–152, March, 1916.)—Evidence has been found of small variations of intensity of certain lines in the spectra of stars whose spectral types are in general very similar. Now if two stars having closely the same type of spectrum differ very greatly in luminosity it is probable that they also differ greatly in size, mass, and depth of atmosphere, which would be likely to produce such minor variations of certain lines of their spectra. The absolute magnitude, apparent magnitude, and parallax being related by known equations, curves were constructed showing the relation between the observed spectral lines, intensity-differences and the absolute magnitude. It being found that for many spectral classes these curves were approximately straight lines, the method has been utilised for determining other parallaxes from the spectral differences. A typical example is given for the stars 61′ Cygni and α Tauri, and a table of results for several stars showing the differences between computed and observed parallax, which are exceedingly small. (Ibid. 2. pp. 152–157, March, 1916.)—The method outlined above is tested by a series of comparisons of results computed for stars whose parallax has been measured by other methods, tables being given for all stars having parallax equal to or exceeding $+0{\cdot}05''$ for which spectrum observations are available. An excellent accordance is shown for most of the stars, but there are several with large discrepancies.

It is anticipated that the method will prove of great value in the selection of star luminosities, when there are available more measured parallaxes of bright stars of small proper motion. C. P. B.

909. *Spectroscopic Evidence for Existence of Two Classes of M Stars.* **W. S. Adams.** (Nat. Acad. Sci., Proc. 2. pp. 157–163, March, 1916.)—The characteristic feature of the M type stars, like α Orionis, is the presence of absorption bands due to titanium oxide. A difficulty arises, however, if the classification be attempted on the basis of the hydrogen lines, as for the other spectral classes on the Harvard system, since for certain of the M stars the hydrogen lines are very faint, while for others they are abnormally strong, and on this basis α Orionis would be in class G2. This distinction appears to be related to the luminosity of the stars. Applying the method already noted for determining absolute magnitudes from the characteristics of certain spectrum lines [see preceding Abs.], it is shown that the M type stars fall into two clearly defined groups, separated by an interval of about seven magnitudes within which no intermediate values have been found. It is suggested that to the symbol for the general class of M stars should be added another denoting the hydrogen classification, distinguishing between stars of high and low luminosity. Thus Mb (G6) would indicate a spectrum in which the bands are strong, but the hydrogen lines give a type of G6. C. P. B.

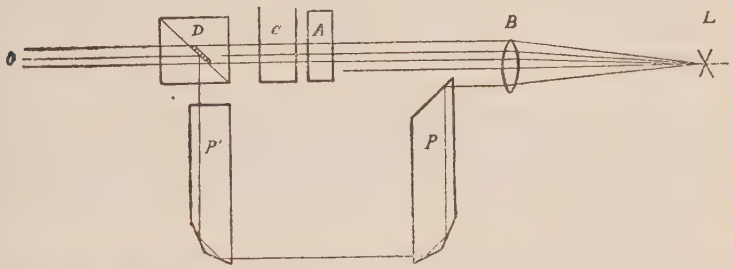
910. *Temperature of Space.* **C. Fabry.** (Astrophys. J. 45. pp. 269–277, May, 1917.)—In considering the theoretical problem of the temperature of space, it is pointed out that in the method of introducing a small testing body it is necessary to take account of its absorptive properties. If it has any selective absorption, it may assume a temperature much lower or much higher than that of a black body, and if the absorption is limited to the short wave-lengths a feeble radiation may develop a very elevated temperature. This seems impossible of realisation in the case of solid bodies, but does not appear improbable for gaseous masses, which would then have the property of emitting, under the influence of the incident radiation, the same radiations which they absorb. Such an explanation would be of interest in affording an explanation of the emission spectra of comets. C. P. B.

911. *Spectrum of δ Cephei.* **W. S. Adams** and **H. Shapley.** (Nat. Acad. Sci., Proc. 2. pp. 136–142, March, 1916.)—Photographs of the spectrum of this variable were obtained at Mt. Wilson with a large spectrograph giving a linear dispersion at H_γ of 5·3 Å to the mm. These show conspicuous differences of spectral type at maximum and minimum light-phase. At maximum the lines of hydrogen and enhanced metallic lines are relatively stronger than at minimum; on the other hand, the lines characteristic of low temperature are stronger at minimum than at maximum. The continuous spectrum is strong in violet at maximum and weakened at minimum. The radial-velocity determinations give + 3·8 km./sec. at minimum, and — 35·2 km./sec. at maximum, being in close agreement with Moore's results obtained at Lick. Analysing the velocities given by the iron lines of varying type as regards pressure shift, it is found that those with large shift show a larger numerical velocity by 1·22 km./sec. Confirmation of the reality of this feature is furnished by the very similar difference found by St. John in the case of solar lines of different pressure type. Other differences in the case of enhanced lines are mentioned, and the explanation is suggested as mainly due to radial convection currents in the stellar atmospheres. The spectrum of the star changes from F4 at maximum to G2 at minimum. C. P. B.

912. *Quantitative Classification of Stellar Spectra.* **W. S. Adams.** (Nat. Acad. Sci., Proc. 2. pp. 143–147, March, 1916.)—The Harvard system of classification of stellar spectra is standardised numerically by introducing comparisons of intensity for certain sets of typical lines, the variations being denoted by decimal steps between the main groups B, A, F, G, K, M, N. The reductions have been made from several thousand photographs of stellar spectra taken at Mt. Wilson with a one-prism slit spectrograph and the 60-in reflector. C. P. B.

LIGHT.

913. *Precision Colorimeter.* **A. L. Bernoulli.** (Archives des Sciences, 43. pp. 384–388, May, 1917.)—Describes the simple form of colorimeter shown in vertical section in the fig. The light from a glow-lamp of about 50 c.p. with frosted bulb is rendered parallel by the lens B. The upper part of this parallel beam passes through the control solution of known concentration contained in the vessel C, and illuminates the peripheral portion of the field of a double prism D constructed after the manner of a Lummer-Brodhun prism. The lower part of the beam passes through the two total-reflection prisms P and P′, which are immersed in the solution under observation. It then illuminates the central portion of the field in D. The distance between P and P′ is measured to about 1/10 mm. by a lens and vernier. The zero of the apparatus is the value of PP′ found when a balance is obtained in D with identical solutions in C and in the lower vessel. This zero is found to be practically the same for solutions of all colours except red. Experiments made with this apparatus show that the absorption is proportional to the concentration to a very close approximation. It is pointed out that the



advantage of the apparatus is that the solution under observation can be contained in a vessel of any size or shape, so that progressive changes of concentration due to chemical reaction can be conveniently followed, while if only a small volume, say down to 1 cm^3, of solution is available, this can be placed in a special vessel at C and compared with the *standard* solution contained in the vessel with P and P′. J. W. T. W.

914. *Improved Form of Phosphoroscope.* **W. S. Andrews.** (Gen. El. Rev. 20. pp. 259–261, March, 1917.)—Certain substances exhibit fluorescence when exhibited to ultra-violet light, and this luminous effect may persist for a short interval after exposure. It is then termed phosphorescence. The apparatus devised by the author is intended to exhibit the latter effect. The instrument consists of a box with two apertures and a blackened interior. One aperture is used for observing the material placed inside, the other for the entrance for the exciting ultra-violet light. The apertures are covered by a rotating shutter with two openings, driven by a small motor operated at such a speed that the rays are alternately admitted and obscured at a rate of 3000–4000 times per min. The shutters are so situated that while the ultra-violet light is admitted the observation window is blocked, and *vice versa.* Accordingly the observer only sees the material for the period during which phosphorescence exists, and the speed is sufficient for there to be no discontinuity in vision. The eye, therefore, sees a surface of invariable

luminosity. The periods of exposure may succeed one another with such rapidity that there is also no time for the phosphorescence to diminish appreciably. Or, by slowing the speed, the phosphorescence may be allowed to diminish and the curve of decay may be studied by calculating, from the speed of the motor, the interval of time between exposure to the source of ultra-violet energy, and to the eye. J. S. D.

915. *Hundred-inch Mount Wilson Reflector.* **G. E. Hale.** (Engineering, 103. pp. 608–609, June 29, 1917. Report from the Mt. Wilson Solar Observatory for 1916.)—In a review of the report of the Mt. Wilson Solar Observatory some details are given of the 100-in. reflector now approaching completion. The clear aperture is 101 in., and focal length 507·5 in. The thickness of the glass is 12·75 in., and its weight is 900 lbs. Two secondary mirrors are provided, giving equivalent focal lengths of 1607 and 3011 in. respectively. C. P. B.

916. *Quartz Spectrograph of Lick Observatory.* **W. H. Wright.** (Lick Observatory Bull. 9 [No. 291]. pp. 52–55, 1917.)—A new quartz spectrograph has recently been constructed in the instrument shop of the Lick Observatory, the optical parts consisting of two 60° quartz prisms of the Cornu type, with simple quartz lenses for collimator and camera, the latter being about 2 in. aperture and 11 in. focal length. A special mounting is shown for attaching the instrument at the principal focus of the 36-in. Crossley reflector. The apparatus is also adaptable as a slitless spectroscope, by using a concave collimator lens, and in this form some of the optical difficulties of adjustment are lessened. An extensive investigation of the spectra of nebulæ is being made, the photographs showing the spectra from λ3000–λ5000. A photograph of the spectrum of the planetary nebula N.G.C. 7662, showing the different character of the images in different wave-lengths, and photographs of details of the instrument are included. C. P. B.

917. *Reflectivity of Tungsten in the Infra-Red.* **W. Weniger** and **A. H. Pfund.** (Frank. Inst., J. 183. pp. 354–355, March, 1917.)—Measures from 0·59 μ to 4·0 μ were made of (1) the absolute reflectivity at room temperature, and (2) the change in reflectivity due to increasing the temperature by stages up to 2056° K. Three tungsten mirrors were used, one polished Coolidge X-ray target, and two polished flat wires mounted in evacuated soft-glass bulbs, with terminals for heating electrically. The spectrometer was provided with a fluorite prism and a bolometer. The length of air-path, number of silvered reflecting surfaces, and angles of reflection from them, were kept constant. The results are summarised below :—

Wave-length, μ.	Absolute Reflectivity at Room Temp. in per cent.	Per Cent. Increase in Reflectivity in going from Room Temp. to—			
		1377° K.	1628° K.	1853° K.	2056° K.
0·67	51	+ 6·0	+ 7·4	+ 8·7	+ 9·8
0·80	55				+ 8·2
1·27	70	0·0	0·0	0·0	0·0
1·90	83	— 6·6	— 8·2	— 9·6	— 11·0
2·00	85	— 7·5	— 9·3	— 10·9	— 12·3
2·90	92	— 7·7	— 9·4	— 11·1	— 12·5
4·00	93				— 12·5

A. E.

918. *Reflection and Refraction Phenomena Relating to a Moving Medium.* **K. Tamaki.** (Kyōtō Coll. Sci., Mem. 2. pp. 59–104, March, 1917.)—Since Fresnel took up (in 1818) the question whether the motion of a mirror had any effect on the laws of reflection and refraction, the problem has been investigated by many prominent physicists. The object of the present paper is to report a study of the important phenomena of reflection and refraction relating to a moving medium when the motion is not, as usual, confined to the direction normal to the surface of separation of two media. In this study the generalised Lorentz-Einstein transformation equations previously obtained by the author are utilised. The results are as follows :—(1) Using these generalised equations, the state of the light disturbance in a medium moving in any direction has been studied. It is found necessary to use the component of velocity along the direction of propagation, instead of its absolute value, when it appears linearly in the expression giving Doppler-effect, and that giving velocity of propagation of light in the moving medium. (2) The laws of reflection at a moving surface have been investigated. The frequency and amplitude of the reflected wave and the angle of reflection in the most general cases have been obtained. The expressions given by Hicks, Harnack, Edser and others, are all contained, as special cases, in the author's expressions. (3) The corresponding important formulæ for the refracted wave in the general case have been deduced up to the term of order v/c. (4) It has been shown that Brewster's law of polarisation holds good even when the reflecting surface is in motion, so far as the first-order effect is concerned. E. H. B.

919. *Application of Plane Grating to Determination of Index of Refraction of a Gas, with values for Air from* λ2500 *to* 6500. **R. W. Dickey.** (Astrophys. J. 45. pp. 189–205, April, 1917.)—The purpose of the investigation was to study the use of the plane grating in extending into the ultra-violet the dispersion curve of a gas. As a test the index of refraction for air has been obtained for different wave-lengths between 2493 and 6412 Å. at intervals of about 200 Å. A brief review of work by previous investigators is given, from Ketteler's in 1865, to the recent research by Miss Howell [Abs. 1394 (1915)], who using a Fabry and Perot interferometer in connection with a quartz spectrograph, has extended the dispersion curve of air to λ 2652 and the curves of H, O, and CO_2 to 2753. The advantage of her method is that it is not necessary to count the number of interference bands going by for a change of pressure, so that the method is applicable to the ultra-violet. The method adopted by the author consists in determining the refractive index of a gas by finding the ratios of the wave-lengths in vacuum and in the gas, by means of a Rowland plane grating with a Littrow type of mounting. It was used by Osborne and Lester [Abs. 52 (1913)] for determining the refractive index of a liquid, but its application to a gas is new. The grating, a 2·5-in. ruled with 15,000 lines to the inch, is covered by a heavy brass bell-jar with the front arranged so that an air-tight quartz window can be inserted. A heating coil wound on the inside walls of a large wooden box surrounding the bell-jar prevents rapid changes of temperature. The entire optical system is made of quartz. A Pfund iron arc serves as source of light. The general procedure is to pump out the bell-jar until the pressure is a small fraction of a mm. of mercury, take an exposure on the photographic plate, then let in the air through drying solutions, and make a second exposure on the same plate. In the later work the scheme of lowering and raising the pressure of the air at intervals of 20 mins. and making all exposures three mins. before,

and three mins. after, letting the air into the bell-jar has been adopted. this way the error due to temperature changes is the same for all observ tions. Since the temperature correction for the shifts of the spectrum lin was not determined, it was necessary to select some iron line whose refracti index for air has been well determined, and refer all values to this lin The line 4315·29 was selected. During preliminary experiments, addition to the horizontal shift of the spectrum lines, a slight vertical sh was noticed, due to deviation of the ray, in passing through the quar window of the bell-jar, from the rarer air within the jar to the denser a outside. The one serious difficulty in the author's method is the effect temperature-changes as the pressure of the gas is changed. It is hoped th with several improvements in the apparatus, the value of this temperatu correction can be determined and consequently the absolute value of $n -$ n being the refractive index. In the present form the method is applicab to gases which do not injure the grating, and for which a single value of t index is known. The corrected values obtained for the refractive index of a are in good agreement with those obtained by other methods. Expressed terms of the Cauchy formula $n - 1 = a + \frac{b}{\lambda^2} + \frac{c}{\lambda^4}$, Miss Howell found the di persion formula of air to be $n - 1 = 10^{-7}\,(2881{\cdot}7 + 11.83/\lambda^2 + 0{\cdot}46/\lambda^4)$. T author finds $n - 1 = 10^{-7}(2878{\cdot}12 + 11{\cdot}59/\lambda^2 + 0{\cdot}551/\lambda^4)$, which is also ne Kayser and Runge's result. A. I

920. *Optical Properties of Selenium Crystals.* **C. H. Skinner.** (Phy Rev. 9. pp. 148–150, Feb., 1917).—Measurements of index of refraction absorption coefficient k, and coefficient of reflection R were made wit a Babinet compensator on a single crystal having a reflection surfac 2 mm. × 5 mm. in the two principal positions: when the principal axis c the crystal was parallel and perpendicular (respectively) to the plane c incidence. The results for various wave-lengths ($\mu\mu$) are as follows:—

λ	First Principal Position.			Second Principal Position.		
	n	k	R	n	k	R
406	4·40	0·458	0·472	2·86	0·320	0·273
441	4·26	0·395	0·442	2·83	0·319	0·269
480	4·12	0·357	0·419	2·77	0·277	0·252
505	4·05	0·317	0·404	2·75	0·276	0·249
550	4·05	0·269	0·393	2·87	0·275	0·264
589	4·04	0·229	0·384	3·00	0·315	0·288
626	4·09	0·188	0·383	3·17	0·184	0·285
668	4·02	0·172	0·374	3·15	1·132	0·276

The angles of principal incidence and principal azimuth are also given and discussed in terms of Drude's theory. The ultra-violet refractive inde 4·40 is the highest known in any substance. E. E. F

921. *Hartmann's Dispersion Formula and the Dispersion of Quartz.* **H Krüss.** (Zeits. Instrumentenk. 37. pp. 1–4, Jan., 1917.)—Hartmann's dis persion formula is $n = n_0 + c/(\lambda - \lambda_0)^a$, n denoting index, λ wave-length, and the other quantities constants. Hartmann recommends 1·2 as the best valu for the exponent a. It remains to find the best values to adopt for the three constants n_0 c, and λ_0. In order to determine these, three new equations ar

obtained by substituting in the original equation three well-observed values of n, with their corresponding wave-lengths. A solution based on the three Fraunhofer lines C, F, H, yields the following values of the constants for quartz : $n_0 = 1{\cdot}52836$, $\lambda_0 = 0{\cdot}120\mu$, $\tan c = 7{\cdot}80443$. A second solution based on the three wave-lengths $0{\cdot}410$, $9{\cdot}274$, and $0{\cdot}198\mu$ yields the values $n^0 = 1{\cdot}52633$, $\lambda_0 = 0{\cdot}1045$, $\tan c = 7{\cdot}86150$. The first set of constants, when substituted in Hartmann's formula, gives concordant results in the visible region, but fails in the ultra-violet spectrum; the second set *vice versa*, though slightly better on the whole. Thus, as was to be expected, Hartmann's formula cannot be applied throughout the spectrum without alteration. The constants must be changed in passing from one limited range of wave-length to another. The discordancy, however, is not nearly so great as with Cauchy's formula. Hartmann has pointed out that his formula is also applicable when for n is substituted a quantity depending upon n. When photographing the whole spectrum on one plate with a rigid quartz spectrograph, the author found the following relation useful for plotting a scale of wave-lengths from $0{\cdot}8 - 0{\cdot}2\mu$: $l = l_0 + c/(\lambda - \lambda_0)$, l denoting an interval on the photograph between two lines (or projected rays). By measuring the positions on the plate of three lines of known wave-lengths, we can calculate intervals on the wave-length scale for the region containing these lines, and slightly beyond it. As in the case of the formula for refractive index, the constants must be changed in proceeding to another region of the spectrum. [Abs. 1241 (1906).] A. E.

922. *Measurement of Small Angles by Displacement Interferometry.* **C. Barus.** (Nat. Acad. Sci., Proc. 3. pp. 412–415, June, 1917.)—Describes a method for the measurement of the small angular displacement of the mirror of an electrometer measuring microvolts. The passage of one interference fringe corresponds to about one microvolt in the apparatus employed. J. W. T. W.

923. *Measurement of Small Angles and a Note on Complementary Fresnellian Fringes.* **C. Barus.** (Nat. Acad. Sci., Proc. 3. pp. 432–436, June, 1917.)—An account of a modification of the method previously described for the measurement of small angles of rotation. In the first case [see preceding Abs.] the angle of rotation of an auxiliary mirror is measured by means of an arrangement of paired mirrors, but in the present apparatus the rotation of the system of paired mirrors is itself measured. The sensitiveness is half that of the first method, but there is greater abundance of light. J. W. T. W.

924. *Long-distance Measurement by Displacement Interferometry.* **C. Barus.** (Nat. Acad. Sci., Proc. 3. pp. 436–437, June, 1917.)—Describes a method, depending on the apparatus for the measurement of small angles [see preceding Abs.], by means of which an object at a distance of about a mile may be located to an accuracy of about 30 ft. J. W. T. W.

925. *Visibility of Interference Fringes and the Double Slit.* **J. K. Robertson.** Nature, 99. p. 424, July 26, 1917.)—The following simple arrangement has been found well adapted for the study of the visibility of fringes arising from a double slit and a "source" slit of variable width. A double slit, ruled without any special care on a piece of old photographic negative, was fixed on the table of a spectrometer after the usual adjustments had been made. With this arrangement and a sodium flame as the source of light, no difficulty

was experienced in observing the disappearance and reappearance of th fringes, with gradually decreasing visibility, some six or seven times. Wit a little practice, estimates of the visibility at successive stages may be mad and the corresponding visibility curve plotted. To make quantitativ measurements, a graduated wheel was attached to the slit of an ordinar Wilson spectrometer, and afterwards calibrated by the aid of a travellin microscope. By this means the width of the slit corresponding to the place of disappearance of the fringes, or to any stage of visibility, could be rea off directly, and a complete set of measurements taken within a short tim In one set of observations the following readings were taken : Width double slit (b) = 0·903 mm. ; focal length of collimator lens (f) = 166 mm. mean value of increase of slit width (w) for successive orders of ze visibility = 0·107 mm. From these we have $\lambda = bw/f = 0{\cdot}000582$ mm. Th quantity w is accurate to about 1 %. A more accurately calibrated spectr meter slit would doubtless permit of greater accuracy in the measurements.

A. W

926. *Absolute System of Colours.* **W[ilhelm] Ostwald.** (Zeits. Phy Chem. 91. 2. pp. 129–142, Feb. 29, 1916.)—As it is at present impossible t order a certain colour except to sample, the author proposes a system base upon the variables purity, tone, and brightness. Every colour tint is mixture of colour and grey, and purity is the proper fraction expressing th ratio colour/grey, the grey consisting of black and white. When a spectrun is superposed on a strip of the colour (paint) in question, the strip will appea brightest at the spot where the two colours are the same, and darkest wher they are complementary ; if the colour were quite pure, the maximum an minimum would be of the intensity of those of a perfect white (barium sulphate) and a black strip. Estimates can be made with the aid of graduate specimens of pure grey, the proportion of white light in which is deter mined by the photometer. If a colour tint consists of pure colour f, white light w, black s, then the brightness (white light = 1) is $h_1 = f + w$, and sinc $f + w + s = 1$ and $1 - h_1 = s$, h_1 will be a proper fraction, and s that part of th light which the tint absorbs under all conditions. The light of the darke spot with the brightness h_2 will exclusively be due to w, so that $h_2 = w$ hence also $f = h_1 - h_2$, that is, the degree of purity is the difference betwee the brightness at the brightest and the darkest spot. Technically the te can be made with the aid of light-filters instead of a spectrum. The valu of f is not dependent upon the nature of the light and upon the eye, and ha an absolute character. The whiteness w, or, better, the ratio $w/(w + s)$ ma be considered as second variable, representing a definite grey or the bright ness ; its determination is given by $w/(w + s) = h_2/(1 + h_2 - h_1)$. The thir variable, the colour tone, is dependent upon the illumination and upon th eye. When the different colours are arranged on the periphery of a circle each tone is polar (diametrically opposite) to its complementary tone ; th principle of inner symmetry further shows that if a and c are two tones no far from one another, and b lies symmetrically between a and c, then the ton of b is that of an additive mixture of a and c. If we divide the circle int 100 divisions, proceeding from yellow to orange, etc., then No. 1 would be represented by sodium picrate (4 % solution in water) or strontium chromat (the yellow ultramarine of painters) ; No. 10 would be dark chrome yellow 20 red lead, 32 carmine, 40 red-violet, 50 reddish blue, 55 ultramarine, 62 Prussian blue, 70 chromium oxyhydrate ; suitable pigments for the remaining numbers, green-yellow, are not easily found. In the analysis of a colour th

author determines, with the aid of a colour-mixing device, that division of the colour circle which, together with the colour in question, will yield neutral grey. H. B.

927. *Theory of Pigments.* I. *Fundamental Properties of Pigments and Size of Grain.* **W[ilhelm] Ostwald.** (Kolloid Zeits. 16. 1. pp. 1–4, Jan., 1915.)—The paper deals with colour [see preceding Abs.], covering power, and effectiveness. Covering power is defined as the area in cm.^{2} of the surface which 1 gm. of the pigment will cover so as to make the underlying surface invisible. Covering power depends upon diffusion and refraction of the incident light; a dark coating of aniline may hide the colour underneath, without having covering power in the proper sense. The effectiveness (*Ausgiebigkeit*) concerns the predominance of a pigment, and is measured by the number of gm. of white pigment with which 1 gm. of the pigment in question must be mixed to make the colour vanish. Prussian blue has the effectiveness 10,000, permanent green only 100. Both the definitions given depend upon the eye and experience of the observer, but they are simpler than others. The grain size influences the three variables strongly. Iron oxide may be bright red to dark violet; the colour and the grain size change on heating, the coarse grains being the darker, whilst cobalt enamel loses its colour when ground fine, brightness and tone changing at the same time. Transparent crystals have no covering power, but gain it on being crushed, to lose it again when the disintegration becomes too fine, of the order of light-waves. The efficiency generally increases on increasing subdivision, and there seems to be no max. limit in this case; some solutions (in molecular subdivision) are most effective; this, however, may only be correct for pigments of considerable absorptive power. H. B.

928. *Hue Difference and Flicker-photometer Speed.* **H. E. Ives.** (Phil. Mag. 34. pp. 99–112, Aug., 1917.)—Reference is made to recent work of L. T. Troland, which suggests that the curve connecting critical speed of a flicker photometer with wave-length throughout the visible spectrum is to be interpreted as the reciprocal of the luminosity curve. This is opposed to the theory of the author as stated in various communications and recently tested by experiments with a special polarisation flicker photometer [Abs. 623 (1917)]. According to this theory critical speed is essentially determined by difference in hue. In the present paper the problem is further investigated theoretically, and additional experiments are made with the polarisation flicker photometer, by the aid of which a number of curves connecting critical speed and wave-length are derived. The predictions of the author's theory are stated to be verified and the data presented, especially those relating to red and blue light, are shown to have no connection with the luminosity curve of the equal energy spectrum. An important point is that the "critical speed" curve is radically affected by the colour of the comparison source used in testing throughout the spectrum, although the luminosity curve of the latter remains unaltered whatever the comparison source. J. S. D.

929. *Gratings as Neutral Dimming Devices in Photometry.* **H. Krüss.** (Zeits. Instrumentenk. 37. pp. 109–120, June, 1917.)—Gives a description of previous work on this subject by Ives [Abs. 1010 (1911)] and others, and describes apparatus consisting of a pair of gratings in which the transmission coefficient is varied, not by rotation of the pair as a whole, but by

the sliding of one grating over the other. The lines and spaces being of the same width, the transmission is thus varied from 0·5 to zero by the movement of a micrometer head graduated in hundredths of a turn. The application of the device to various types of photometer is described and illustrated, and a discussion is given of the relation between the effect of the position of the device, and the perception by the eye of the lines and spaces in the photometer field. J. W. T. W.

930. *Photographic Photometry.* **J. Baillaud.** (Ann. de Physique, 5. p. 131, 1916. Zeits. Instrumentenk. 37. pp. 54–57, March, 1917.)—Describes in detail, with a diagram, a photometer which is used with a scale of blackening suited to the photographic plates employed. The instrument is not a microphotometer of the Hartmann type, though very small surfaces may be used in it. A. W.

931. *Relation between Sunlight and Moonlight.* **J. S. Dow.** (Illum. Eng., London, 10. pp. 113–114, April, 1917.)—Taking sunlight to be equivalent to 10,000 candle-ft. (for perpendicular incidence from an unclouded sky), the corresponding illumination from the full moon is calculated to be 0·02 candle-ft. The author finds this to be very near the value he obtained by actual measurement. The range of illumination between sunlight and moonlight is thus of the order of 1 to 500,000. C. P. B.

932. *Precision Method of Uniting Optical Glass. Union of Glass in Optical Contact by Heat Treatment.* **R. G. Parker** and **A. J. Dalladay.** (Faraday Soc., Trans. 12. pp. 305–312; Disc., 312–313, June, 1917. Chem. News 114. pp. 310–313, Dec. 29, 1916. Phil. Mag. 33. pp. 276–286, March, 1917. Engineering, 103. pp. 23–24, Jan. 12, 1917.)—Owing to the numerous defects of cements available for constructing glass cells for examination of optical properties of liquids, a new process, by which a much more perfect union between two pieces of glass can be obtained, has been developed. The surfaces to be united are so worked and polished that they are either both plane or of the same curvature to a very high degree of accuracy. They are then pressed together in "optical contact," and if they are subjected to carefully controlled heating will unite and become one piece. It is essential that the temperature at which union takes place shall not only be far below the melting-point of the glass, but also considerably below the annealing temperature (at which a badly annealed piece of glass when heated would become sufficiently mobile to lose all internal strain), for even at this temperature very slight strain would cause sufficient deformation of worked glass surfaces to render them useless.

The mobilty of glass has been found to be an exponential function of the temperature, namely: $S_T = S_t A^{(T-t)/N}$, where S_T, S_t are the "mobilities" at temperatures T, *t*, measured by the rate of deformation of glass under constant stress. The quantity N is comparatively small. In a typical example, with $N = 8$, $A = 2$, $T = 560°$ C., it is shown that the glass becomes twice as "soft" for every rise of temperature of 8 deg. C. Therefore, at 60 or 70 deg. C. below the annealing temperature the glass is sufficiently hard to withstand very great local pressure for short periods without sensible deformation. Working at this temperature 60 deg. C. (or for safety 10 or 20 deg. lower) below the annealing point, two pieces of glass under pressure, and in optical contact, will unite perfectly in less than an hour. Ordinary optical contact can easily be destroyed by sudden temperature change, by

action of liquids, or by mechanical normal force; but glasses united by the new method cannot be separated by these means, and a crack or cut spreads through the two pieces as though one piece of glass, whereas in ordinary optical contact it cannot be made to pass from one piece to the other. Details of experiments in construction of cells of one kind of glass are described. The joining of glasses of different kind is complicated by at least three factors—difference of expansion coefficient, difference of annealing point, and capability of fusing together in the blowpipe flame. The first will cause strain to appear, owing to different contraction in the glasses when cooling after joining, but for some purposes it may not matter. Such strain as this cannot be obviated by annealing. If the annealing points differ by more than about perhaps 50 deg., there will be difficulty in joining. The annealing points of glasses in common use range over 250 deg.; the flint and crown glasses commonly used in object glasses were found to differ too widely in annealing temperature for successful union. It appears that certain kinds of glasses which will not fuse together readily in the blowpipe flame will also not unite by the new method. A polarimeter tube having windows permanently fixed in position by this new method was prepared without difficulty. The tube was of soda-lime glass, and the windows of plate-glass; max. temp. 470° C. The join was perfect, and although different glasses were employed the windows showed no strain sufficient to interfere with measurements of rotation. It is intended to apply this construction to jacketed tubes. Some experiments on union of fused silica indicate that a temperature of about 1100° C. will be required to give results as good as those attained with glass. A. E.

933. *Investigation of Radium Luminous Compound.* **C. C. Paterson, J. W. T. Walsh,** and **W. F. Higgins.** (Phys. Soc., Proc. 39. pp. 215–246; Disc., 246–249, June, 1917.)—An account is given of the testing of luminous compounds composed of zinc sulphide to which is added a small amount of radium. The luminosity of the material is due to the action of α-particles from the radium impinging on the crystals of zinc sulphide. Measurements of brightness are rendered difficult by (1) the green hue of the light emitted, and (2) the very low brightness. The authors describe methods of obviating these difficulties, involving comparison with the light of a glow-lamp of known candle-power, transmitted through a suitable green glass (such as B. O. T. light green) giving a close colour-match. If small portions of the material are to be tested these are conveniently made the background to a slit in the illuminated white surface in the photometer.

In testing luminous dials it is found preferable to place the dial to be tested between two opaque metal dials with stencilled figures, behind which is placed a translucent surface illuminated by light from a glow-lamp, transmitted through appropriate green glass. The current through the lamp is then adjusted until the brightness of the figures on the three dials appears equal. An investigation into the best size for the figures on dials is summarised. The authors also describe the method of measuring the radium content, by comparison with a standard consisting of a known amount of a radium salt, by an ionisation method. The latter part of the paper is devoted to measurements of the decay in luminosity. This may be due partly to discolouration of the glass containing material, or of the binding substance, if applied as varnish, caused by the action of radium emanations. But decay is mainly due to action on the zinc sulphide itself, which loses the power to luminesce in the course of time. In general the material attains a max. brightness in 10 to 20 days after mixing, and then diminishes in luminosity, at first

rapidly and afterwards more slowly. Curves are presented showing the nature of the decay for material containing 0·1, 0·2, 0·3, 0·4, and 0·6 mgm. of Ra per gm. of composition. The max. brightness is roughly proportional to the Ra-content, but the brighter compositions decay more rapidly. The curve is at first approximately logarithmic, but in the later stages the brightness falls less rapidly than such a relation would suggest. Considerations governing the choice of compound in practice are discussed. It is shown that in general the minimum useful Ra-content is about 0·2 mgm. per gm. J. S. D.

934. *The Pathological Effects of Radiant Energy on the Eye.* **F. H. Verhoeff, L. Bell,** and **C. B. Walker.** (Am. Acad., Proc. 51. pp. 630–793, July, 1916.)—A complete monograph on the subject. It is impossible here to do more than reproduce a few of the general conclusions as being of special physical, as opposed to physiological, interest.

(1) The liminal exposure capable of producing photophthalmia to the extent of conjunctivitis accompanied by stippling of the cornea, is in terms of energy about 2×10^6 erg secs. per cm.^{2} of abiotic radiation of the character derived, for example, from the quartz lamp or the magnetite arc. About $2\frac{1}{2}$ times this exposure is required to produce loss of corneal epithelium.

(2) The abiotic action of the cornea and conjunctiva produced by any radiating sources follows the law of inverse squares and is directly proportional to the total abiotic energy received. It can therefore be definitely predicted from the physical properties of the source.

(3) Commercial illuminants are found to be entirely free of danger under the ordinary conditions of their use. The abiotic radiations, furnished by even the most powerful of them, are too small in amount to produce danger of photophthalma under ordinary working conditions even when accidentally used without their globes. The glass enclosing globes used with all practical commercial illuminants are amply sufficient to reduce any abiotic radiations very far below the danger point.

(4) Under ordinary conditions no glasses of any kind are required as protection against abiotic radiations. L. H. W.

935. *Investigation of Metallic Fogs.* IV. *Effect of Light on Solid Silver Chloride and Bromide.* **R. Lorenz** and **K. Hiege.** (Zeits. Anorg. Chem. 92. 1/2. pp. 27–34, June 18, 1915.)—Metallic fogs are colloidal in nature. Crystallised salts can be coloured by bringing the salt (unfused) in contact with fused metal (Pb with $PbCl_2$); the ultramicroscope shows in these products particles of finely-divided metal. The silver haloids form fogs also when exposed to light. The cone of light (Lorenz and Eitel) first remains optically empty and invisible in the crystal, although the salt turns brown and violet. The authors now show that clear crystals of AgCl and AgBr, free of all fogs, become modified by illumination in the same way as by metallic fogs. Thus the view, already predominant, is supported, that the latent photographic image is due to ultramicroscopic particles of metallic silver, and not to sub-haloids. When the exposure to light is continued, bright points appear which grow in size; the growth also takes place when the crystal, after exposure for 2 minutes, is heated to 350° for 6 hours. On the other hand, the particles disappear when the salt is treated with nitric acid; heating alone does not lead to the appearance of particles. [See also Abs. 1347 (1915).] H. B.

936. *Methods in Reversed and Non-reversed Spectrum Interferometry.* **C. Barus.** (Am. J. Sci. 42. pp. 402–420, Nov., 1916, and 43. pp. 145–162, Feb., 1917.)—Describes in detail a number of experiments made with the apparatus designed by the author for exhibiting the properties of reversed and non-reversed spectra. The paper does not admit of brief abstract. [See Abs. 71, 776, 1035, 1038 (1916).] A. W.

937. *Bleach-out Colour Photography.* **J. H. Smith.** (Manchester Lit. and Phil. Soc., Mem. 60. 9. pp. 1–15, April, 1917.)—A *résumé* of work done on the bleach-out process of colour-photography, based on the principle that chemical decomposition is effected by those of the incident rays which are absorbed. Applications, *inter alia*, to the author's "Uto" (1904) and "Uto-color" (1911) paper are mentioned. A. D.

938. *Interference Colours of Quartz in Polarised Light.* I. **T. Liebisch** and **A. Wenzel.** (Preuss. Akad. Wiss. Berlin, Ber. 1. pp. 3–22, 1917.)—The Young–Helmholtz theory of colour sensation was applied by Koenig and Dieterici to a quantitative investigation of the series of interference colours seen in polarised light in four groups of apophyllites. Proceeding on similar lines, the authors apply the theory to quantitative analysis of the interference colours shown in polarised light by a thin wedge of quartz, with edge perpendicular or parallel to the optic axis. Near the end of the paper some figures are given showing a series of meridian curves on wave-fronts. A. E.

939. *Anomalous Dispersion of Metallic Vapours.* **A. S. King.** (Mt. Wilson Solar Observat., Contrib. No. 130. Astrophys. J. 45. pp. 254–268, May, 1917.)—The electric furnace has been employed as a method of producing the more refractory metallic vapours under conditions which give anomalous dispersion, and at the same time permit control of the temperature and distribution of the vapour by which variations of the phenomena could be studied. Tables are given of the lines of iron, chromium, and titanium showing the degree to which they are affected. Provided that the vapour absorbing a given line has a non-uniform distribution equivalent to a prism, it is found that the anomalous dispersion is proportional to the strength in absorption. Lines showing strong effect at low temperatures can often be made to show refraction in the opposite direction at higher temperatures. In the case of mixed vapours of different refractory powers, there may thus be exhibited at the same time anomalous dispersion in opposite directions; or lines belonging to the same element may show this phenomenon if they are such as appear at different temperatures, a typical example being the case of λ4227 and $\lambda\lambda$3933, 3968, due to calcium. The general result is that each element in a mixture of vapours is capable of giving its own anomalous dispersion independently of the others present. The anomalous dispersion is shown stronger for lines in the regions of shorter wave-length, probably owing to the greater absorptive power generally found for lines in this region, as when suitable lines are found in the red the effect is as great as for the violet lines. Distinct evidence of anomalous dispersion was found for the band at λ3883. No evidence was found for mutual repulsion of close lines, and no change of wave-length was found when a line in the regular furnace spectrum occurred very close to a strong line known to show strong anomalous dispersion. C. P. B.

940. *Rotation of Constant-deviation Prisms.* **W. E. Forsythe.** (Astrophys. J. 45. pp. 278–284, May, 1917.)—For certain work it is advisable that the constant-deviation prism should always be used at minimum deviation,

and a method is described whereby this condition may be realised, together with the rotation of the prism for different wave-lengths. The axis of rotation is defined as the intersection of the bisector of the angle between the incident face and the base with the reflecting surface of the prism. When the prism is rotated about this point there will be no lateral shifting of the beam, and the wave-length calibration will not depend on the character of the spectroscope lenses. A simple method is described for locating the position of the prism on the prism-table by means of stops, so that it may be easily replaced after removal. C. P. B.

941. *Mutual Attraction between Photographic Images.* **H. H. Turner.** (Roy. Astron. Soc., M.N. 77. pp. 519–521, April, 1917.)—An old instance of apparent distortion of a reseau line by the image of a bright star near by led to the examination of the Oxford plates for any similar effect by all stars brighter than 4·5 magnitude. No other case was found. A further series of tests were made by measuring a copy of a reseau made by double exposure, with the reseau turned through nearly 90° between the exposures. By measuring the separation of two gradually converging lines it was found that when near the crossing-point the separations became less than the theoretical values, suggesting some mutual effect between the two photographic images which only becomes effective at a certain distance. [See Abs. 47 (1917).] C. P. B.

942. *Spectroscopic Field-light.* **F. E. Fowle.** (Astrophys. J. 45. pp. 213–224, May, 1917.)—To investigate the amount of scattering leading to divergence of energy in spectroscopic measurements, bolometric records have been made with a rock-salt prism of the radiation from a Nernst lamp, with and without a quartz plate 5 mm. thick placed in front of the spectroscope slit. The quartz plate is nearly transparent to $\lambda 4\mu$, and opaque beyond. The results show that the intensity of the light scattered from any region amounts to about 3 % of the true intensity of that region. This was for silver-on-glass mirrors in good condition. When badly tarnished the effect is considerably more marked. C. P. B.

943. *Accuracy of Rowland's Solar Spectrum Wave-lengths.* **C. E. St. John.** (Nat. Acad. Sci., Proc. 2. pp. 226–229, April, 1916.)—Various attempts have been made to find simple methods of transference of spectrum wave-lengths from the standards furnished by Rowland's measures of the solar spectrum to the international series based on laboratory measurements of the electric arc, and if it is desired to be true to the third decimal. As it is now known, however, that for lines of the same pressure group the displacements between sun and arc are, among other relations, a function of the line intensity, it is evident that no factor of transformation nor a curve can yield true differences between the two systems for all lines even for a limited region. The author gives the reassuring statement that for measurements on plates of very high dispersion he concludes that the accidental errors in Rowland's wave-lengths are much less than one-hundredth of an Angström. C. P. B.

944. *Harmonics in the Infra-red Absorption Spectra of Diatomic Gases.* **J. B. Brinsmade** and **E. C. Kemble.** (Nat. Acad. Sci., Proc. 3. pp. 420–425, June, 1917.)—Kemble has recently called attention to the fact that if the energy of the vibrational motion of the charged atoms of diatomic gases takes on only the quantum values, the corresponding infra-red absorption bands in the spectra of such gases ought to be accompanied by faint harmonics. Only one case (carbon monoxide) was hitherto known to exist, in

which more than one band was present, and this was a faint one at very nearly half the wave-length of the fundamental. The present paper gives a preliminary report of an experimental search for similar harmonics in the infra-red absorption spectra of other diatomic gases, and an examination of their structure. First harmonics have been found in the absorption spectra of HCl and HBr, and their structure, as well as that of the faint CO band, has been shown to be in general agreement with the theory of Bjerrum and v. Bahr. Search was also made for possible second and third harmonics in the spectra of CO and HCl, but without result. There seems to be no reason to doubt that it is correct to conclude from the discontinuities in the structure of the infra-red absorption bands of diatomic gases, that the angular velocities are distributed among the molecules in the discontinuous manner predicted by the older form of the quantum theory. The existence of harmonics in the infra-red spectra of these gases is almost equally good evidence that the vibrational energy of these molecules is distributed in the same manner. A. W.

945. *The Reversed Spectrum.* **A. Kirschmann.** (Phys. Zeits. 18. pp. 195–205, May 1, 1917.)—A descriptive article dealing with special spectra in which instead of a slit a "half-slit" is used, *i.e.* the light is allowed to pass an opaque edge and then the prism refracts and disperses the light passing that edge. If the dark part, or opaque body, lies on the side of the refracting angle of the prism, then the spectrum begins with red and ends with greenish yellow. If the half-slit is turned round so that the bright part is on the side of the refracting angle of the prism, then the spectrum shows the colours blue, ultramarine, and violet. E. H. B.

946. *Spectra of Some Intermetallic Compounds.* **G. Tammann.** (Zeits. Anorg. Chem. 92. 1/2. pp. 76–80, June 18, 1915.)—The compounds which make up a large portion of the alloys are chiefly known in the anisotropic state; their molecules probably exist also in the liquid and gaseous states, but little is known about their dissociation in these states. From the electric conductivity of liquid alloys Bornemann concludes that the degree of dissociation of fused alloys with large heat of formation is not considerable; Wartenberg (1914) found vapours of $MgZn_2$ completely dissociated at 1300°, but Na_3Hg little dissociated at 440°. The comparison of the spectra of compounds and of mixtures of their components does not admit of ready interpretation. When brass electrodes are used in air, the spectrum is that of Cu, of Zn, and of the gases; in hydrogen the arc is difficult to maintain; there is less difficulty in nitrogen, but enclosed arcs are required, so that working in air is, after all, simplest. The author uses arcs of about 4·5 cm., 35 volts, 4·5 amps., and a Krüss quartz spectrograph, fusing his alloys for making the electrodes; two electrodes of the different metals would, in the arc, not be under the same conditions. The spectrum of Cu_3Sb showed all the lines of the two metals and no more. Similarly with Zn_3Cu_2, Ni and Sb. In these cases (low heat of formation) the dissociation is complete or considerable. But in the cases where the heat of formation is high, Mg_3Sb_2 and other alloys of the two metals, the Mg lines are strong, the Sb lines weak. In general the alloy spectrum is the sum of the spectra of the two components for alloys of low heat of formation; when the heat of formation is great, certain lines (Mgλ285·2, which inclines to reversal) may be missing, and this reversal is favoured by Bi and Sn, but not by Sb. On the whole, spectrum analysis is not very suitable for the recognition of intermetallic compounds in mixtures. H. B.

947. *Spark and Vacuum Arc Spectra in Ultra-Violet.* **T. Takamine** and **S. Nitta.** (Kyōtō Coll. Sci., Mem. 2. pp. 117–135, March, 1917.)—The spark spectra of Ag, Al, Au, Bi, Cd, Co, Fe, Mn, Pt, Sb, and Tl, in the extreme ultra-violet, were investigated by means of a quartz spectrograph, using Schumann plates. Relying on the data given by L. and E. Bloch for the Ag and Fe sparks, the wave-lengths of the spectrum lines were measured for the above metals in the region λ2000–1830 Å.U. A number of new lines were found for each element, especially in the most refrangible part. The spectra of Mn and Pt in this region were investigated for the first time. About 60 lines were observed for each of these metals in the region under investigation. Employing a vacuum arc lamp provided with a Wehnelt kathode, the vacuum arc spectra of Bi, Sb, and Tl were photographed with the same apparatus. Several new lines were found for each in the above region.

A number of photographs are reproduced. A. W.

948. *Third Line-Spectrum of Oxygen.* **A. Fowler** and **J. Brooksbank.** (Roy. Astron. Soc., M.N. 77. pp. 511–517, April, 1917.)—Under the influence of intense discharges from a 12-in. induction coil with varying capacities in the secondary circuit, the authors have found that the vacuum-tube spectrum of oxygen shows a set of lines additional to the two groups previously known as the "compound" and "elementary" line spectra. The observations extend from λ7000 to λ2000. The lines of OIII are very numerous in the ultra-violet, but there are no conspicuous members of the new spectrum between Schuster's and Roscoe's λ5592 and Lunt's line at λ3961·8, which are the only lines of the new spectrum previously on record. For celestial comparisons there are few stellar spectra available in the ultra-violet region, but tables are given showing that the evidence for the presence of OIII lines in stars is fairly consistent; chiefly in stars of B type and the Wolf-Rayet stars. C. P. B.

949. *Arc Spectra of Cassiopeium, Aldebaranium, Erbium and of the Thulium Elements.* **J. M. Eder.** (Akad. Wiss. Wien, Ber. IIa. 127. No. 8. Chem. Zentralblatt I. pp. 242–243, 1916.)—The measurements were made with a concave grating of 4·6m. radius and electrodes of pure retort carbon and with salts prepared by Welsbach. Cassiopeium sulphate, $Cp_2(SO_4)_3 + 8H_2O$, gives a brilliant blue-green light; 260 lines were measured between λ7237 and 2392; there is also a characteristic band spectrum. Exner and Haschek spoke of 5 lines common to Cp and aldebaranium (Ald); 4 of these are due to Ald, the fifth to thulium. The aldebaranium sulphate (same composition) gave 630 lines, 420 of which are due to Ald; the band spectrum is less characteristic. Various thulium preparations were studied. The Ald-Thulium I gave new lines ascribed to a new element denebium (from star Deneb in the Swan); Ald-Thul II gave the lines of impure thulium, probably due to neothulium; a third preparation gave new lines ascribed to dubhium (from Dubhe, in the Great Bear). The purified erbium salts yielded 2800 lines, and as many more on prolonged exposure; the spectrum seems to be very complex. H. B.

950. *Influence of Water of Crystallisation upon the Fluorescence and Absorption Spectra of Uranyl Nitrate.* **E. L. Nichols** and **E. Merritt.** (Phys. Rev. 9. pp. 113–126. Feb., 1917.)—The authors have examined the spectra of the three hydrates, the hexahydrate, trihydrate, and dihydrate, of uranyl nitrate and find that in the case of each of the salts the fluorescence spectrum is made up of a series in which the

intervals between bands are constant and the same for all of the series. The interval increases slightly, but unmistakably, as the amount of water of crystallisation decreases. For the hexahydrate the interval is 86·0; for the trihydrate 86 8; for the dihydrate 88·1; and for the anhydrous salt 88 5. Numerous constant-interval series occur in the absorption spectrum, the interval being approximately 71. But the interval does not appear to be the same for different series even when these occur in the spectrum of the same salt. No systematic variation with the amount of water of crystallisation could be detected. Nearly all of the series in the absorption spectrum have their origin in the "reversing region," the first member of the absorption series being in coincidence with the last member of a fluorescence series and constituting a "reversible" band. There is some slight resemblance between the different hydrates as regards the grouping of the bands. In each case a certain short interval appears with a frequency considerably above the average. In the case of the hexahydrate and the dihydrate, this interval is about 8; in the case of the trihydrate it is almost exactly 7. The interval 14 in the case of the trihydrate, and 16 in the case of the other two salts, is also of unusually frequent occurrence, and it will be of interest to determine whether this peculiarity in the distribution of intervals is characteristic of all uranyl salts. The authors find, also, that the different spectra are not in the least similar in their general appearance. On the whole, the spectra of the different hydrates differ from one another fully as much as do the spectra of two different uranyl salts. This result is surprising, since it is customary to think of water of crystallisation as rather loosely attached and therefore incapable of exerting great influence upon properties which depend on the internal structure of the molecule. In the uranyl salts it appears that we must look upon the connection as more intimate than has generally been supposed. The results obtained also tend to confirm the view that fluorescence spectra are due to vibrations which occur in the outer parts of the molecule and which are therefore readily modified by the outside sources of disturbance. A. F.

951. *Triplet Series of Radium.* [Miss] **G. A. Anslow** and [Miss] **J. T. Howell.** (Nat. Acad. Sci., Proc. 3. pp. 409–412, June, 1917.)—The spectra of the elements of the second group of the periodic table are characterised by the presence of both doublet and triplet series of the principal, first, and second subordinate types. On plotting the logarithms of the atomic numbers against the logarithms of the frequency-differences between the extreme members of the triplets, it was found that alternate elements fall on straight lines. Hence the triplets of radium should fall on the line on which Ca, Sr and Ba lie. From this it follows that the frequency-difference of radium triplets should be approximately 3060. An examination of the known radium lines, as measured by Runge and Precht, showed a number of triplets with the average frequency-difference $\nu_1 = 2016{\cdot}64$, $\nu_2 = 1036{\cdot}15$. giving $\nu_1 + \nu_2 = 3052{\cdot}79$. Two triplets showed well-marked satellites and seemed to belong to the first subordinate series. Although a study of the magnetic resolution of these lines will be necessary to establish the triplets, there seems little reason to doubt that the frequency-difference 3053 is characteristic of the radium spectrum. Plotting the logarithms of the frequency-differences against the logarithms of the atomic weights gives similarly a pair of straight lines. Extrapolation gives in one case 87 for the atomic number, and in the other case 231·6 for the atomic weight—values quite close to the true values, 88 and 226. A table is given of the triplets

identified up to the present, with tentative Rydberg formulæ for the three series. A. W.

952. *Theory of the Rotation Spectrum.* **M. Planck.** (Ann. d. Physik, 52. 5. pp. 491–505, June 7, 1917.)—Consequent on the work of Bohr [Abs. 1930 (1913)], Sommerfeld and Epstein [Abs. 49 (1917)], it has been established that the realm of spectroscopy is governed by the quanta hypothesis, yet the dynamic procedure of emission and absorption of radiation is still obscure. Not even the fundamental problem, as to whether the precedence assigned by the quanta theory to the so-called static orbit of the oscillating ions or electrons before all other orbits is justified, has yet been solved in such a definite manner as to indicate whether it is one of several possible orbits or whether the static orbit possesses distinctive properties which render it unique. The former conception of Einstein is the more general, being based on the comprehensive theory of heat radiation. The chief difficulty which arises is that in every move of an absorbing oscillator from a static orbit of smaller energy to one of greater, a portion of energy is abstracted from the surrounding radiation field, a process which is not in accord with the finite propagation velocity of the radiation and with a finite radiation density—a difficulty which for some time back led the author to the conclusion that the static orbits are not the only ones possible, but that they are the only ones in which emission of radiant energy can ensue. This hypothesis has the advantage that it is compatible with those absorption laws derived from classical electrodynamics, and the prospect arises, by further pursuit of this view and testing of its consequences, of finding a positive answer to the question as to whether a contradiction with experience will be found. Should the latter be the case the abandonment of the classical theory of absorption will be inevitable. For this purpose the study of the absorption spectrum produced by the rotation of a rigid electric dipole will be an excellent means of investigating the application of the laws of classical dynamics to the mechanism of absorption and comparing the results with experiment. Here the constitution of the absorption diagram is unchangeable, while the method of rotation is known. Apparently there will now be a contradiction of the facts, since the rotation spectrum is not continuous, but canalised according to the angular velocity of the rotation, thereby exhibiting more or less sharp absorption maxima, and thereby pointing to the conclusion that by sufficient dilution of the absorbing gases, *i.e.* when the influence of the impact of the molecules is sufficiently reduced, the maxima can be produced as quite sharp dark lines with bright intervals. This view from the standpoint of the classical theory points to the absorption of radiant heat by only such molecules as possess the necessary rotation velocity; and since according to the above theory the absorption is certainly not bound up with a definite angular velocity, it follows that no other than the particular rotation velocities are present in gases—a fact which from the standpoint of the quanta theory produces the static orbits of the rotating molecules. It follows that a molecule possessing no definite rotation velocity changes as soon as absorption commences. There is a continual exchange of vibration frequencies between the molecules. The author gives a detailed mathematical exposition of the above argument, using fixed axes of rotation. The case for free axes will be given in a future communication. The classical absorption theory applied to the rotation spectrum leads to the definite demand that the spectral distribution density with increasing rotation velocity should assume the form of a step series

with horizontal steps of equal width. The step width corresponds to the spectral difference of two neighbouring absorption bands; the height, to the intensity of the absorption. This result agrees entirely with the conditions for the derived equilibrium state of the rotating molecules obtained from purely thermodynamical considerations. While it has not yet been proved that the classical theory of the absorption of radiant heat corresponds to actual reality, nevertheless this theory applied to the phenomena of the rotation spectrum cannot as yet be relinquished in the quanta theory.

H. H. Ho.

953. *Stark-effect in Helium and Neon.* **H. Nyquist.** (Nat. Acad. Sci., Proc. 3. pp. 399–401, June, 1917.)—A modification of Lo Surdo's method was adopted, which obviated some difficulties met with when using the Lo Surdo type of discharge tube. The disadvantages of the Lo Surdo discharge tube are that the walls of the tube are quickly covered with a metallic film due to sputtering, and the tube breaks easily on account of the heating. In the apparatus used in the present experiments these difficulties are overcome by having within the discharge tube proper an inner tube of Al, through which the discharge takes place, and which has a slit through which the light passes. Opposite this slit there is a side tube having a window at its end. The Al is not seriously affected by the heat, and the trouble from sputtering is eliminated. A 13,200-volt transformer was employed, the current being rectified by two kenotrons and a suitable arrangement of condensers and inductances. The results obtained show that the equation connecting the displacement of a component and the electric field is of the form $\delta\lambda = a + bE$, where a is not zero for many components. When $a = 0$, b is positive. Only two exceptions to the latter rule have been found: He 4686 and He 3965. Simple numerical relations exist connecting the values of a for the different components of a given line. Such numerical relations exist to a less degree between the values of b. The effect in the line He 4686 agrees qualitatively with that predicted by Evans and Croxson on Epstein's theory. The numerical value of the ratio of the distance between the outer components of H_3 to that of He 4686, however, was found to be $24/(3^2 - 2^2)$ instead of $24/(4^2 - 3^2)$ as predicted by them. Two new lines of the same type as those discovered by Koch were observed in helium. In neon, 34 such lines were observed. A diagram is given illustrating the various types of resolution observed.

A detailed statement of the results together with a full description of the apparatus and method will be published later. A. W.

954. *Infra-red Absorption Spectrum of Naphthalene and Compounds.* **A. H. Stang.** (Phys. Rev. 9. pp. 542–553, June, 1917.)—Baly has predicted from theoretical considerations at what wave-lengths the infra-red absorption maxima of several substances should occur. Among these substances was naphthalene. The object of the research here dealt with was to investigate the absorption of naphthalene and of some of its mono-derivatives, and especially to obtain the positions of max. absorption. Since these substances are solids at ordinary temperatures, it was decided to obtain their absorption curves when in solution in carbon disulphide and carbon tetrachloride. These solvents were chosen on account of their relative transparency in the infra-red. The experiments covered a range from 2·7 μ to 10 μ, and tables and diagrams of results are given for the substances dealt with. The results show that bands which are present when one of the solvents is used are nearly

always present, or are indicated by breaks, in the curve when the other solvent is used. Although the positions of max. absorption are generally the same in both solutions, the general appearance of the absorption curves may be very different. Several absorption bands occur which are due to the benzene nucleus. The mono-derivatives of naphthalene have several of the absorption bands of naphthalene itself, but there are many others which are characteristic of the derivative itself. Those naphthalene bands occurring in the α-derivative are generally present in the β-derivative, and there are always several other bands common to both derivatives. The infra-red absorption curve of the α-derivative is, however, as a whole, different from that of the β-derivative in the same solvent. In agreement with Baly's theory it was found that nearly all wave-numbers of absorption bands for these substances in the visible region possess, as integral factors, two or more infra-red absorption maxima wave-numbers. [Abs. 1258 (1914).] A. W.

955. *Stark-effect on Hydrogen Lines.* **T. Takamine** and **U. Yoshida** (Kyōtō Coll. Sci., Mem. 2. pp. 137–146, March, 1917.)—Howell recently studied the effect of an electric field on certain lithium and calcium lines [Abs. 134 (1917)]. He states that the results obtained by Lo Surdo and Puccianti are somewhat different from those of Stark. In fact, instead of the many components observed by Stark, Lo Surdo found two p-components in all the lines H_α, H_β, H_γ and H_δ, and s-components agreeing in number with the term-number of the series. The experiments here described were undertaken with the view of deciding the question. Lo Surdo's method was employed, and considerable care was taken in the preparation of the discharge tubes. The following results were obtained:—For H_γ, in addition to the two outer p-components and the three s-components, which were obtained by former investigators with Lo Surdo's method, four inner p-components and two inner s-components were obtained, and these were clearly identified with certain components obtained by Stark. Relying on the data given by Stark for H_γ, the field strength was calculated, and the distribution of the electric field in front of the kathode was determined. If E_0 is the field intensity at the end of the dark space, the quantity $E - E_0$, so far as the present experiments are concerned, seems to increase nearly in proportion to the square of the distance from that end. For the inner p- and s-components it was found that the separation is approximately symmetrical, and is also proportional to the intensity of the electric field. The effect of the electric field on certain lines belonging to the secondary spectrum of hydrogen was also investigated, and many interesting modes of separation were found. Further results dealing with H_α, H_β, and H_γ will be given later. A. W.

956. *System of Absorption Bands in the X-ray Spectra of the Elements and the Importance of Selective Absorption Phenomena in Radiography.* **de Broglie.** (Comptes Rendus, 163. pp. 352–355, Oct. 9, 1916.)—The author emphasises the fact already stated by Boll and Mallet [Abs. 1036 (1917)], that the rays from a Coolidge tube are as heterogeneous as those from an ordinary bulb. The photographic spectra of the rays emitted in both cases are similar. They show two very intense continuous bands due to the selective absorption of the rays in the bromine and the silver of the photographic film, and both K and L radiations are present. It is pointed out that the K- and L-rays are not much used in radiography. It is the continuous spectrum, reinforced by the selective absorption of the rays in the film, that plays the most important part, and probably radiography would be far more difficult were it not for this selective absorption in the film.

When the voltage on the tube is raised, the radiation emitted is modified in a way almost analogous to that which takes place when a black body has its temperature raised. The absolute intensities of all the radiations increase whilst the relative intensities are modified to the profit of the short wave-lengths, and on the average the radiation becomes more penetrating.

By passing the rays through an Al screen almost all the L-rays are suppressed and the bands are limited more and more as the thickness of the screen increases, on the side of the longer wave-lengths. If the screen is sufficiently thick, very great monochromatism may be reached. A practically monochromatic beam may, however, be obtained by placing in the path of the rays a screen containing a body of atomic weight slightly greater than that of Ag. This screen absorbs sensibly all the penetrating radiations except those in the narrow band which lies between the top of the absorption band due to the screen, and the border of the band which arises from the silver of the film. The spectrum given under these conditions shows the phenomenon in a very striking manner. E. A. O.

957. *Study of the L-series of Elements of High Atomic Weight.* **R. Ledoux-Lebard** and **A. Dauvillier.** (Comptes Rendus, 164. pp. 687–690, April 30, 1917.)—On account of the uncertainty which seems to exist with regard to the structure of the L-series of elements of high atomic weight, the authors have made a detailed examination of the L-series of W, Pt, Au, and Ir. The results verify the relation $\nu = A(N - 7{\cdot}4)^2$, (where ν is the frequency, N the atomic number, and A a constant), for the intense rays of greatest wave-length (α), but wide and progressive divergencies are noted at higher frequencies as the value of N increases. Similar observations have been made on the K-series of W and Pt, and in the case of the "M-radiations" for the heavy elements, the above relation in these cases being $\nu = A'(N - 20)^2$.

The series of W, Ir, and Pt are represented graphically, the relation between $\sqrt{\nu}$ and N for different frequencies, being a series of parallel straight lines indicating a progressive change in the value of the number inside the brackets in the expression for the frequency. A. B. W.

958. *The K-series of Tungsten.* **R. Ledoux-Lebard** and **A. Dauvillier.** (Comptes Rendus, 163. pp. 754–757, Dec. 11, 1916.)—The authors have examined the rays emitted by a tungsten antikathode in a Coolidge tube. Plotting the voltages applied to the tube against the max. frequencies of the rays emitted, it is found that the curve obtained deviates more and more as the voltage increases, from the theoretical curve $h\nu = eV$ given by the quantum theory, where h is Planck's constant. The K-series of tungsten is found to make its appearance when the voltage applied to the tube is 80 kilovolts. The series consists of four lines arranged in two doublets whose wave-lengths are as follows :—

$\alpha_1 = 0{\cdot}2128 \times 10^{-8}$ cm. (feeble ray), $\alpha_2 = 0{\cdot}2053 \times 10^{-8}$ cm. (very intense ray),
$\beta_1 = 0{\cdot}1826 \times 10^{-8}$ cm. (feeble ray), $\beta_2 = 0\,1768 \times 10^{-8}$ cm. (feeble ray).

The rays α_1, α_2 are not excited until the ray β_1 is excited, that is, one of the components of the shorter wave-lengths must be excited before the longer wave-lengths are produced. The continuous spectrum of the rays from the bulb presents quite a different appearance before, from what it does after, the excitation of the characteristic rays. Whereas in the first case, the max. energy of the spectrum is in the shorter wave-lengths, in the second case it is localised in the characteristic rays and the energy in the remainder of the spectrum is greatly diminished.

The authors state that probably the most penetrating X-rays that can be produced to a very intense degree, are those of the K-series of uranium with a wave-length of $0{\cdot}1086 \times 10^{-8}$ cm. [Abs. 726 (1916)]. E. A. O.

959. *Relations between the Spectra of X-rays.* **J. Ishiwara.** (Math. Phys. Soc., Tōkyō, Proc. 9. pp. 160–166, July, 1917. Nature, 99. p. 424, July 26, 1917.) —Kossel has found the following relations between the frequencies of X-ray spectra :—

$$L_\alpha = K_\beta - K_\alpha \ldots (A), \quad M_\alpha = L_\gamma - L_\alpha \ldots (B).$$

According to Malmer, relation (A) should take the form $L_{\alpha_1} = K_{\beta_1} - K_{\alpha_2}$ (1). Adopting the values for the wave-length given by M. Siegbahn (Jahrb. d. Radiakt. u. Elecktr.) we have instead of (B)

$$M_\beta = L_{\gamma_1} - L_{\beta_4} \ldots (2), \quad M_{\gamma_1} = L_{\gamma_2} - L_{\beta_1} \ldots (3).$$

The following relations also hold very exactly among the elements :—

$$L_{\alpha_2} - L_{\beta_2} = L_{\beta_1} - L_{\gamma_1} = L_{\beta_3} - L_{\gamma_2} + \Delta \ldots (4), \text{ where } \Delta \text{ is a constant.}$$

In order to account for these relations, especially (4), the author proposes a modification of Bohr's theoretical formula connecting X-ray frequencies and atomic numbers. A. B. W.

960. *Broadening of X-ray Spectrum Lines.* **H. Seemann.** (Phys. Zeits. 18. pp. 242–249, June 1, 1917.)—The author examines the various ways in which X-ray spectrum lines are broadened as a result of the finite width of the slit and the finite depth of the "active" layer of the crystal, *i.e.* of the layer of molecules at the surface of the crystal, which are effective in reflecting appreciably the incident X-rays. A comparison is drawn between the "slit" and "edge" method of limiting the incident beam of X-rays. In the former case the beam is restricted by a slit of lead placed in the path of the rays ; in the latter a sharp edge of lead is placed almost in contact with the crystal surface, in which case an apparent slit is formed by the lead edge and the surface of the crystal. Diagrams are shown to illustrate the different ways in which the beam is reflected from various depths of the "active" layer in the two cases. Excellent photographs are reproduced indicating that the "slit" method is considerably superior to the "edge" method when sharp, bright and narrow spectrum lines are required. Even with fairly wide slits the lines are narrower than those obtained with the straight edge method ; the photographs with narrow slits being beautifully sharp and the lines remarkably narrow in comparison. It is clearly shown that the thickness of the "active layer" of crystal is important when considering the question of the broadening of spectrum lines. A. B. W.

961. *Absorption of X-rays.* **T. E. Aurén.** (Phil. Mag. 33. pp. 471–487, June, 1917.)—The author has determined the relative absorption coefficients of several elements for a heterogeneous beam of X-rays from a tungsten anti-kathode, the absorbing screens being in the form of solutions. In calculating the relative atomic absorption coefficients from the values of the relative molecular absorption coefficients, it is assumed that the absorption of the solution is additively determined by the absorption of the constituent atoms. It is found that the molecular absorption coefficient is independent of the concentration of the solution examined. The relative atomic absorption coefficients of a number of elements ranging in atomic weight from that of hydrogen to that of uranium are given, and it is concluded that no simple relation such as that found by Bragg and Pierce, namely that the atomic absorption coefficient is proportional to the fourth power of the atomic number,

exists between the atomic number of the absorbing atom and the atomic absorption coefficient. It is found, however, that the graph drawn with atomic number and atomic absorption coefficients as arguments, exhibits a grouping of the elements, the atomic absorption coefficients of elements in each group being directly proportional to the atomic numbers. The relation between the different groups appears slightly more complicated. E. A. O.

962. *Röntgen Rays from Sources other than the Focal Spot in Tubes of the Pure Electron Discharge Type.* **W. D. Coolidge** and **C. N. Moore.** (Gen. El. Rev. 20. pp. 272–281, April, 1917.)—This investigation was undertaken to determine the source and amount of extraneous radiations from electrodes of the Coolidge tube, and to find to what extent these radiations affect radiographs of the human body. It consisted mainly in a pinhole-camera-picture study of various forms of the tube. Röntgenograms made with the standard hot-kathode tube showed that the entire target, including the molybdenum stem and the adjacent end of the iron support tube, gives off Röntgen rays, and must therefore be bombarded by kathode rays from some source or other. The production of Röntgen rays from the entire surface of the target is accounted for by the reflection of kathode rays from the focal spot. These reflected kathode rays come from the focal spot with almost as high a velocity as that with which they approach it, but on account of the repulsion of the charges on the kathode and on the glass they are forced to go back and strike the target again. This process is continuous. The röntgenograms show that those surfaces of the kathode structure which face the anode also give off Röntgen rays. These are secondary X-rays produced by the primary X-rays coming from the target. Over a wide range of voltage there is approximately 1/9 as much radiation from the body and stem of the target as there is from the focal spot, the former being but slightly less penetrating than the latter. Various devices are described for minimising radiation other than that from the focal spot, but the conclusion arrived at is that the part played by these extraneous rays is too small to warrant the use of any one of the methods described to minimise it. E. A. O.

RADIO-ACTIVITY.

963. *Laws of Radio-active Transformation.* **A. Debierne.** (Ann. de Physique [IX], 4. pp. 309–322, July–Aug., 1915.)—When a radio-active transformation yields a single radio-active atom and an atom of helium, then $dn_1 = -\lambda_1 n_1 dt$, where n_1 is the number of atoms transformed in the time t, and λ_1 the velocity constant of the substance A. In successive changes $A \longrightarrow B \longrightarrow C \ldots dn_2 = \lambda_1 n_1 dt - \lambda_2 n_2 dt$, etc.; Curie has shown how to pass by formula from n to $(n+1)$ substances. The author suggests another way of regarding the mechanism of transformation and gives a formula for groups of atoms without considering the successive changes separately. Each atom has its particular "destiny." A will be A for the time t_1, then B for the time t_2 . . . and finally t_n. From experiment he calculates the number of atoms which have sensibly the same destiny. The number of atoms A existing for the time t_1 is $n_1 = N_0 e^{-\lambda t_1}$, where N_0 indicates the number of atoms of A existing at time t_0. To simplify he assumes that at that moment only A exists; then $dN_1 = N_0 e^{-\lambda_1 t_1} dt_1$. The general equation of destiny is—

$$dN_{1,2\ldots n} = N_0 \lambda_1 \lambda_2 \ldots \lambda_n e^{-\lambda_1 t_1} e^{-\lambda_2 t_2} \ldots e^{-\lambda_n t_n} dt_1 dt_2 \ldots dt_n.$$

The probability of a certain transformation can also be deduced. H. B.

964. *The Mechanism of Radio-active Changes and the Constitution of the Atom.* **A. Debierne.** (Ann. de Physique [IX], 4. pp. 323–345, July–Aug., 1915.)—Though the fundamental laws of radio-active transformation are identical with the laws of chemical reactions, there are found essential differences, and the understanding of radio-activity requires some very special hypotheses concerning the constitution of the atom and physical agents. The peculiarity is that radio-active transformations are spontaneous and cannot be provoked or influenced by external agencies. The author has himself tried electric discharges, a magnetic field, low and high temperatures, and radiations, without any result; the fact that radium compounds are as active as the metal shows that chemical combination has no influence. Yet differences of 1 % might be overlooked, and evidence of external influence will probably be found. Thermal agitation, which so powerfully affects all reactions, may be regarded as a general element of disorder. That element of disorder might exist also in radio-active substances, and yet temperature need not affect radio-activity. There might also be other elements of disorder, *e.g.* a very penetrating force or radiation so far unknown. The atom would have to be much more complex than now supposed; the internal temperature should be infinitely higher than the external—since the projected particles must be in equilibrium with the intra-atomic agitation—and that view would necessitate the existence of an impermeable envelope of the atom, possibly of the nature of surface tension. The atom would be divided into several regions. On the outside would be the elements establishing connection with external phenomena, the easily detached electrons of gaseous ionisation; the electrons of electrolytic ionisation would more strongly be bound; near these would be the elements (electrons and magnetons) which determine special radiations and valency—all this intermediate region being the seat of chemical affinity, subject to temperature and radiation influences. In the interior are the principal constituents of the atom, the sub-atoms, held together by unknown powerful forces. Helium is one of the sub-atoms; the nucleus is the seat of radio-active-transformations, disordered, but constant in their mean state. Although the life periods of α-particles range from a fraction of a second to thousands of years, the mean period varies indirectly as a certain power of the velocity of emission. The element of disorder of molecular agitation may or may not be different from the element of intra-atomic disorder. The radio-active nucleus must contain many very small elements of disorder and probably also electrons, since β-rays are emitted at high speeds. Yet the nucleus must have a very small volume; hence the internal forces are all the stronger perhaps. H. B.

965. *Use of Radium Emanation in Sealed Tubes.* **A. Laborde.** (Comptes Rendus, 164. pp. 811–813, May 21, 1917.)—*Apropos* of a note by Debierne and Regaud on this subject. Researches of H. Dominici have shown that the γ-rays, which represent only a small fraction of the energy of radium radiations, were sufficient to account for the important physiological effects, although the γ-rays are only very slightly absorbed in the tissues on which they act.

Clinical experience also indicates that for rays of a definite quality very different effects are produced according as they are used in great intensity for a short time, or in weak intensity for a correspondingly long time. The duration of the application does not seem to be sufficient to compensate for the lack of intensity of the rays.

Three factors are of great importance in the clinical application of radium rays : (1) the radio-active power of the product employed, (2) the duration of the application, and (3) the quality of the radiations called into play.

With these points kept in view, various methods of "applying" sealed tubes of radium emanation are discussed, and a working formula for clinical purposes is deduced. A. B. W.

966. *Actinium/Uranium Ratio in Colorado Carnotite.* **K. H. Fussler.** (Phys. Rev. 9. pp. 142–147, Feb., 1917.)—If actinium is a branch product of the uranium series there should be a constant ratio between the activities of the Ac and of the Ur in all uranium minerals. Since this ratio has been directly measured for only *one* uranium mineral and for only *two* specimens of that mineral [Abs. 1100 (1908)], the author thought it desirable to determine the ratio for another uranium mineral. This paper describes the experiments carried out with Colorado carnotite.

The values for the relative activity of the actinium series obtained in these experiments were 0·135, 0·176, and 0·107 × Ur. Boltwood's weighted mean of similar observations was 0·28 for the actinium/uranium ratio. A. B. W.

967. *Retardation of α-particles by Metals.* **H. J. Vennes.** (Am. J. Sci. 44. pp. 69–72, July, 1917.)—Marsden and Richardson [Abs. 812 (1913)] have shown that the amount by which a metal foil reduces the range of α-particles depends on the part of the range in which the foil is placed. The "air equivalent" of the foil was shown to be considerably greater when placed directly over the source than when placed near the end of the range. The author has now carried out experiments, (*a*) by the scintillation method —as used by Marsden and Richardson, and (*b*) by the "point-discharge" method of counting the α-particles. In the latter method the α-particles are fired through a small hole in a cylindrical chamber containing a central fine wire connected to a string electrometer. A p.d. of 1500 volts is maintained between the "point" of the central wire and the surrounding cylinder. The entry of each α-particle produces a "kick" of the electrometer fibre.

The result of these experiments indicates that in any investigation where the range of α-particles must be determined the point-discharge method is equally as well adapted as the scintillation method. A. B. W.

968. *Inquiries into Radium Disintegration.* **T. C. Choudhari.** (Chem. News, 116. pp. 25–27, July 20, 1917.)—This communication is mainly concerned with the disintegration of radium halide in aqueous solution, and also to some extent with disintegration in the solid condition of the salt. The author's conclusions are summarised as follows :—During the disintegration of a radium halide in aqueous solution the excess of hydrogen cannot be satisfactorily explained by any *one* cause, and may perhaps be due to the consumption of oxygen, partly by ozonisation and partly by peroxide formation. When radium halide disintegrates the gradual diminution in weight cannot be attributed to the gradual disruption of its radium-content alone, but is due to the quantity of metallic Ra disintegrated, *plus* its equivalent quantity of halogen set free.

The fate of the halogen-content in radium halide when metallic Ra has completely disintegrated, giving rise to emanation, remains unexplained. A. B. W.

HEAT.

969. *Self-registering Differential Dilatometer.* **P. Chevenard.** (Comptes Rendus, 164. pp. 916–918, June 11, 1917.)—The dilatometer is designed for use in connection with the thermal analysis of steels and the study of the dilatation of special alloys. It traces automatically a curve representing the *difference* of expansion between the metal studied and a standard metal whose behaviour is known within the range of temperature investigated. The standard metal employed in the study of steels is an alloy of nickel and chromium (10 : 100) known as "baros," this alloy being not easily oxidised and possessing a heat capacity about equal to that of steel; it is non-magnetic, and its law of dilatation almost exactly reversible, and represented between 0° and 900° C. by a parabolic formula.

The metals are in the form of cylinders 50 mm. in length, contained in silica tubes side by side (closed at one end), and heated electrically. The temperature is obtained from the known curve of expansion of the standard rod, and is checked by comparison with a le Chatelier couple. Two silica rods are in contact with the ends of the metals at one end, and with an optical lever at the other. The latter magnifies the expansion 300 times.

Curves are given for ferro-nickel, pure nickel, and electrolytic iron. The curve for ferro-nickel shows the anomalous contraction which accompanies magnetic transformation. This contraction is found to be a maximum for a composition corresponding to the formula Fe_3Ni, and tends towards zero for a content of 68 of Ni per 100 Fe. From this proportion to the state of pure Ni the singularity reappears, but in a different sense. Peculiarities are also observed and discussed in the case of electrolytic iron. T. B.

970. *The Kinetic Theory of a Composite Monatomic Gas.* **S. Chapman.** (Roy. Soc. Phil. Trans. 217. pp. 115–197, June 25, 1917.)—Contains the detailed mathematical development of the theory previously published in a summarised form [Abs. 147 (1917)]. The complete analysis brings out the hitherto unrecognised fact that the motion of interdiffusion of two gases at a uniform temperature is accompanied by a flow of heat, which is proportional to the velocity of diffusion and also depends on the temperature and the molecular densities, but is independent of the other characteristics of the gas. This the author calls the "thermal flux of diffusion." The "specific energy of diffusion" is greater the greater the difference between the masses and sizes of the molecules. The expression for the thermal conductivity, which is very complex, differs from that given previously [Abs. 636 (1912)], allowance now being made for the above-mentioned diffusion phenomenon. The expression for the viscosity is also very complicated even in the first approximation; but the theory verifies (as proved previously by Maxwell and Kuenen) that the viscosity of a gas mixture may, for a certain ratio between the numbers of each molecule per unit volume, rise to a maximum which exceeds that of either constituent.

An interesting application worked out in the paper is that of the variation in the concentration of the oxygen and nitrogen in the atmosphere that would be expected in the absence of convection currents. Owing to the gravitational field the heavier gas is relatively denser in the lower strata when the steady state is attained. The ratio of the numbers of oxygen and nitrogen molecules present would thereby alter by 1/5 % per km., while, due to the

temperature gradient (taken as 7° C. per km.), the ratio would alter in the opposite direction by 1/30 % per km. D. O. W.

971. *Modifications of the Dilatability of Invar by Thermal and Mechanical Actions.* **C. E. Guillaume.** (Comptes Rendus, 163. pp. 654–658, Nov. 27, 1916.)—Since 1898, the author has been aware of the fact that quenching or cold-working results in a sensible diminution of the dilatability of invar and also that the two actions can be superimposed until the dilatability actually becomes negative, *i.e.* a bar will contract on heating. This has been recently confirmed by numerous accurately conducted measurements. After air-cooling from 900° C., a bar of invar had a dilatability of $+ 0{\cdot}65 \times 10^{-6}$, but when drawn into wire 1·65 mm. in diam. and quenched the value was found to be $- 0{\cdot}53 \times 10^{-6}$, a total change of $1{\cdot}18 \times 10^{-6}$. The max. change effected by combined wire-drawing and quenching was $2{\cdot}18 \times 10^{-6}$. "Ageing" (heating to a moderately high temperature for the purpose of stabilising) removes the diminution in the dilatability fairly rapidly. At 250° C. the effect produced by quenching practically disappears, but only 50 % of that produced by cold-working is removed. F. C. A. H. L.

972. *Changes in the Dilatability of Iron-Nickel Alloys under the action of various Thermal and Mechanical Treatments.* **C. E. Guillaume.** (Comptes Rendus, 164. pp. 904–906, June 11, 1917.)—The work described in a previous Paper [see preceding Abs.] has been extended to other iron-nickel alloys containing 27·5 to 69 % nickel. Alloys containing below 28 % Ni have their dilatabilities increased by thermal treatment and also by drawing into wire. From 28 to 55 % Ni the alloys behave like invar [*loc. cit.*], the diminution in the dilatability gradually decreasing as the Ni-content increases. In the 69 % alloy the changes are only of the order of 1/20 of those observed in invar after similar treatment. F. C. A. H. L.

973. *Mechanical Hardening and Dilatability of Invar.* **C. E. Guillaume.** (Comptes Rendus, 163. pp. 741–744, Dec. 11, 1916.)—Wires for surveying purposes are coiled up for the purpose of convenience and transport, and in coiling and uncoiling, the fibres are subject to elastic deformations which increase as the diam. of the coil decreases. In order to determine the quality of the wire and to establish a relative criterion of the mechanical hardening to which the material has been subjected it is wound to a coil 100 mm. in diam. and allowed to uncoil naturally, when the dimensions of the coil to which it expands is taken as a measure of the suitability of the wire. Experience has shown that the diam. of the resulting coil must be at least 180 mm. under these conditions; 200 mm. represents good material, while above 250 mm. the wire is of excellent quality. Ageing at 100° C. does not appreciably affect the dimensions of the unrolled coil, but at 250° C. the effect is slightly to increase the diam. Simultaneous determination of the uncoiling diam. and the dilatability shows that as the former increases the latter decreases. Thus the mechanical hardening of the alloy has a very real effect on the dilatability. Cold-work produces an effect independent of the apparent hardness and this effect is only brought to light by a determination of the dilatability. F. C. A. H. L.

974. *Methods and Apparatus used in the Cryogenic Laboratory.* XVII. *Cryostat for Temperatures between 27° K. and 55° K.* **H. K. Onnes.** (K. Akad. Amsterdam, Proc. 19. pp. 1049–1058, 1917. Com. No. 151*a* from the Phys.

Lab., Leiden.)—A cryostat is described in which, by means of a current of hydrogen warmed to the desired temperature and passed through the experimental chamber, constant and uniform temperatures in the range 27°–55° K. are obtainable. The temperature remains constant to within 0·01 deg. for half an hour or more and to within 0·02 deg. for longer preliminary periods. In its present construction the hydrogen-vapour cryostat is not suitable for experiments in which the phenomena in the experimental space have to be followed by the eye, as this space is surrounded by copper walls. T. H. P.

975. *Isothermals of Monatomic Gases and of their Binary Mixtures.* XVIII. *Preliminary Determination of the Critical Point of Neon.* **H. K. Onnes, C. A. Crommelin,** and **P. G. Cath.** (K. Akad. Amsterdam, Proc. 19. pp. 1058–1062, 1917. Com. No. 151*b* from the Phys. Lab., Leiden.)—By means of the hydrogen-vapour cryostat [see preceding Abs.] measurements of the critical data of neon have been made. The measurements are, however, only of a preliminary character, since the neon employed contained small amounts of admixed gases, which resulted in a gradual increase of pressure during condensation ; in measurements with the same apparatus of the vapour pressure of hydrogen in the immediate vicinity of the critical point, no such differences were encountered, owing to the fact that the hydrogen was purified by distillation. The results now obtained for neon are : Critical temperature, —228·35° C. ; critical pressure, 26·86 atmos. These data confirm the supposition that argon and neon, regarded from the point of view of the law of corresponding states, differ but little from each other [Abs. 89 (1916)]. T. H. P.

976. *High-pressure and Temperature Phenomena. Solar Heat Theory of Arrhenius.* **E. Briner.** (Journ. Chim. Phys. 13. 4. pp. 465–487, Dec. 31, 1915.)—Starting from the atoms [Abs. 1298 (1916)], all combinations are exothermic. So-called endothermic compounds are so merely because their heat of formation is referred to the elements under ordinary pressure and temperature conditions. The endothermicity of combinations, whose constituents are gaseous under those conditions, results from the fact that the heat of formation, when starting from the atoms, is smaller than the heat of formation of the constituent molecules. If with rising temperature dissociation affects the molecules of the constituent elements, combination by exothermic reaction will pass through a maximum. At very high temperature, but moderate pressures, the destruction of all combinations will be complete, and contrary to other views, the medium will be in the elementary conditions. This is supported by the researches of Grotrian and Runge that the cyanogen bands are really due to nitrogen. In the case of hydrogen the author, making use of Isnardi and Langmuir's experiments and Nernst's heat theorem, shows that the dissociation influence of temperature would be very strong up to 6000° when, at ordinary pressure, 99 % of the molecules would be dissociated into atoms ; but if at that temperature the pressure were raised to 100,000 atmos., only 2 % would be dissociated. In the case of NH_3, at very high temperatures and moderate pressure we should find N and H atoms exclusively ; at very high pressures and moderate temperatures only molecules of NH_3 ; in the interval NH_3, N_2, H_2, N, H would occur. A similar calculation is made for NO. The extreme temperatures and pressures cannot be realised in the laboratory, but exist probably in stars. According to Arrhenius compounds exist in the interior of the sun which, carried to the surface, decompose with explosive energy under enormous evolution of heat

and vast expansion. This view is criticised as untenable, and it is pointed out that no other manifestations, so far known of chemical affinity, could account for the solar heat. But the dissociation need not, in the cosmos, stop at the atomic stadium ; there may be further disintegration, the interior of the sun might, *e.g.*, contain the proto-atoms of N. Lockyer. H. B.

977. *Improvements in Calorimetric Combustion, and the Heat of Combustion of Toluene.* **T. W. Richards** and **H. S. Davis.** (Am. Chem. Soc., J. 39. pp. 341–354, March, 1917.)

978. *The Vapour Pressure of Ice.* **S. Weber.** (Kongl. Danske Vidensk. Selskabs Forh. p. 459, 1916. Zeits. Instrumentenk. Beibl. 5. pp. 41–43, March 1, 1917.)—The object of these experiments was to investigate the vapour pressure of ice at very low temperatures, and to obtain, if possible, new foundations for the truth of formulæ showing the dependence of vapour pressure on temperature. The principal difficulty in such measurements is the fact that at very low temperatures the vapour pressure becomes extremely small, *e.g.*

Temp.	Vapour Press. of Ice.
0° C.	4·579 mm. of Hg.
— 25° C.	0·480 „ „ „
— 63° C.	0·003 „ „ „
— 98° C.	0·000015 „ „ „

and previous results are not to be relied on below 60° C. A statistical method was adopted, the pressure being measured by an absolute manometer, which was sensitive to a difference of pressure of 0·001 dyne/cm.², and a Wollaston hot-wire manometer. Special care was taken to have the necessary correction for thermo-molecular pressure as small as possible. Control measurements were made with a mercury manometer, temperatures being registered by a Pt-resistance thermometer. The water used was obtained partly by repeated distillation, partly by synthesis.

Experiments were conducted at temperatures from — 22° to — 193° C. The results were placed in a number of tables, and are found to agree very well with the vapour-pressure formula due to Nernst:

$$\log p \text{ (mm. Hg)} = -2611{\cdot}7/T + 1{\cdot}75 \log T - 0{\cdot}00210\,T + 6{\cdot}5343.$$

T. B.

979. *Influence of Method of Heating on the Emissive Properties of Platinum and Tungsten.* **A. G. Worthing.** (Phys. Rev. 9. pp. 226–227, March, 1917.)—Describes measurements of the red and blue brightnesses of very thin ribbons of Pt and W raised to incandescence (i) by absorption of radiation, and (ii) by electric current. No differences between the blue brightnesses at a given red brightness could be detected with certainty in either case.

J. W. T. W.

980. *The Clément and Desormes Experiment.* **G. Guglielmo.** (N. Cimento, 12. pp. 195–212, Nov., 1916.)—A revision of the author's previous method [Abs. 1996 (1914)] of calculating the ratio of the two specific heats, with a discussion of the nature and the amount of the possible errors. A direct determination is made of the mechanical equivalent of heat by means of the Clément and Desormes apparatus. A. D.

981. *The Joule-Thomson Effect in Superheated Steam. I. Experimental Study of Heat-leakage.* **H. M. Trueblood.** (Am. Acad., Proc. 52. pp. 784–

804, June, 1917.)—The author some time ago made measurements of the Joule-Thomson effect (μ) in superheated steam, and also of its product by the specific heat at constant pressure (μC_p). He realised then that the control or the elimination of heat-leakage in these experiments was of the greatest importance, and the present work is an attempt to secure this and hence obtain reliable values of μ. If μ is the true, and $\mu'(=\Delta T_1/\Delta p)$ the apparent Joule-Thomson effect, f the flow (mass of fluid passing in unit time), δQ the heat leakage in unit time, C_p the specific heat at constant pressure, and ΔT and Δp respectively the temperature and pressure drops (assumed so small that μ and C_p may be assumed constant), then $\Delta T = \mu.\Delta p - \delta Q/fC_p$...(1); hence $\mu'(=\Delta T/\Delta p) = \mu - \delta Q/f\Delta pC_p$...(2).

To eliminate the effect of heat leakage, experiments at approximately the same pressure and temperature, but with different rates of flow, must be conducted. The flow may be varied without varying the temperature drop by using different plugs; or the pressure drop and the flow together may be varied, using the same plug throughout. The second method was found to be simpler and to give the most consistent results.

It is an experimental fact that a curve obtained by plotting μ' against $1/f$ is a straight line. Data and curves are given in confirmation of this. Hence the "leakage term" in (2) must be of the form $\delta Q/f\Delta pC_p = A + B/f$...(2a), where A and B are constants. It can also be assumed that $A = 0$; otherwise δQ would contain a term proportional to $f\Delta p$, which is shown to be extremely improbable.

Hence μ may be calculated from *any* point in the straight line mentioned above by adding B/f to the ordinate at this point (ΔT, Δp or μ').

Measurements have been made with several types of throttling apparatus. The various types may be classed as (1) "Radial flow," where the plug is so shaped as to cause the fluid to flow through it in a direction parallel to the leakage temperature gradient; (2) "Axial flow," where the flow is perpendicular to this gradient. One type was specially designed to investigate the effect of variation in lagging, since "internal lagging," *i.e.* lagging between the metallic support of the plug and the high-side fluid, is the remedy for a secondary leakage effect in the radial flow apparatus known as the "regeneration effect." The result of this effect is that the observed temperature effect is too high.

Most of the numerous experiments were made at practically the same temperature and pressure, and the work is therefore, at this stage, of little value to those who are primarily interested in the thermodynamics of superheated steam. Experimental work at other points is promised in a future paper. For details of apparatus, figures, and diagrams, the original paper, which is very full and detailed, should be consulted. The value of the Joule-Thomson coefficient in steam at 165° C. and 3·86 kg./cm.^{2} is given as 3·182 deg. C. per kg. per cm.^{2}. This agrees within less than 1 % with the mean results of Grindley, Peake, and Griessmann at the same temperature. The existence of a small positive pressure coefficient $(\partial\mu/\partial p)t$ is indicated, of the order 0·028 deg. C. cm.^{4}/kg.^{2}. T. B.

982. *Poisson's Laws and the Aeriform State in relation to the First Law of Thermodynamics.* **G. Guglielmo.** (N. Cimento, 12. pp. 145–156, Oct., 1916.)—Further discussion of this question [see Abs. 1996 (1914)].

T. H. P.

983. *Calculation of Heat of Vaporisation of Non-associated Liquids.* **A. Albertosi.** (Journ. Chim. Phys. 13. 4. pp. 379–389, Dec. 31, 1915.)—

Starting from the assumption—to be explained in another paper—that the attraction between two spherical molecules varies directly as the product of the masses and inversely as the sixth power of the distance, the author gives the formula for the latent heat of vaporisation :

$$(a)\ \mathrm{L} = \alpha(\vartheta^{5/3} - \vartheta_1^{5/3}) - \beta\vartheta_1 - (1 - \vartheta_1/\vartheta) + p(v_1 - v),$$

where v and v_1 are the volumes of unit mass of liquid and saturated vapour, ϑ and ϑ_1 the densities (reciprocals of v), and α and β constants. At low temperature ϑ_1 becomes very small and the second term vanishes (formula (b)). Since further at low temperatures $\vartheta_1^{5/3}$ is very small, the formula assumes the shape $\mathrm{L} = a(\mathrm{A} - \mathrm{BT}) + \mathrm{RT} = \mathrm{A}_1 - \mathrm{B}_1\mathrm{T}$ [see next Abs.]. It is shown by tables of data (hydrocarbons CCl_4, CO_2) mainly taken from S. Young, that formula (b) agrees with observations within 0·2 to 0·5 %. It is finally pointed out, however, that the formula of Mills (1906) : $\mathrm{L} = a(\vartheta^{1/3} - \vartheta_1^{1/3}) + p(v_1 - v)$ also agrees within 1 to 3 %, though Mills assumes an inverse square law.

H. B.

984. *Thermal Dilatation of Liquids below the Normal Boiling-point.* **A. Albertosi.** (Journ. Chim. Phys. 13. 4. pp. 390–398, Dec. 31, 1915.)—By combining the formula of Gibbs-Dupré for the change of vapour pressure with temperature : $\log p = m/\mathrm{T} + n \log \mathrm{T} + z$, m, n, z being constants, with the thermodynamical formula of Clausius : $d\mathrm{T}/dp = \mathrm{T}(v_1 - v)/\mathrm{L}$, and by substituting for L the value of formula (b) [see preceding Abs.], the author finds $\vartheta^{5/3} = \mathrm{A} - \mathrm{BT}$, presuming that saturated vapour obeys the law of Boyle-Mariotte. This formula expresses the thermal dilatation of liquids—non-associated again—with a remarkable approximation, as is shown by data due to S. Young, Pierre, and Kopp. The constant A represents the theoretical density at absolute zero, and can be deduced from observations at two temperatures T_1 and T_2, $\mathrm{A} = (\mathrm{T}_2\vartheta^{5/3} - \mathrm{T}_1\vartheta_2^{5/3})/(\mathrm{T}_2 - \mathrm{T}_1)$. H. B.

985. *Kinetic Theory of Gases.* **C. del Lungo.** (N. Cimento, 12. pp. 166–175, Oct., 1916.) — The equation $pv = \mathrm{M}u^2/3$ (Joule 1851, König 1856, Clausius 1857) implies that the temperature depends solely on the kinetic energy and that a compressed gas does not contain more energy than a rarefied one at the same temperature, so that potential energy is not stored up, in the ordinary sense, in a compressed gas. In unit volume $p = \frac{2}{3}(\rho u^2/2) = \frac{2}{3}$ the molecular kinetic energy per unit of volume ; *i.e.* p is proportional to the energy density. The different proofs of the equation $pv = \mathrm{M}u^2/3$ have not all the same value. In Joule's scheme the gas is supposed divided into three equal portions, each travelling parallel to a rectangular co-ordinate ; this harmonises with unconstrained motion as regards the resultant pressure, but not as regards isotropy (n, v, nv in different directions). The product nv measures the flux of particles across unit of area : on this depend internal friction, diffusion, thermal conduction ; on Joule's model these would be different in different directions. In Clausius' model all the particles have equal velocities, these being in all directions from a point of origin. Clausius' model is taken as the basis of a more general treatment, applicable whatever the distribution of the molecular velocities. The result is $p = \mathrm{N}mu^2/3$, where u^2 is the mean of the squares of u ; but there are preponderating incidences as regards the number of impacts ($\theta = 45°$) and as regards the pressure (43° 53°). Maxwell's law of distribution of kinetic energy and therefore of velocities (1860) is considered. The problem is worked out afresh as one of statistical probabilities : Maxwell

was correct, though his proof was at first inconclusive. Maxwell's postulate, objected to by some mathematicians (Bertrand and others) and defended by P. G. Tait, Borel, and others, is shown to be a necessary primitive property of the function which solves the problem of statistical equilibrium among a very large number of particles after a very large number of impacts. A. D.

986. *Atomistics.* V. *Corresponding States and Volume at Absolute Zero.* **R. Lorenz.** (Zeits. Anorg. Chem. 94. 2. pp. 240–254, Feb. 29, 1916.)—So far the heat theorem of Nernst and his rule as to the constancy of the behaviour of expansion coefficient and specific heat afford the most exact method of calculating the volume of a substance at absolute zero from the liquid state. The doctrine of corresponding states enable us, however, to utilise many of its chemical and physical data, though the method is neither new in principle, nor very exact. According to van der Waals $V_0 = b = \frac{1}{3}V_K$, or $V_K/V_0 = 3$, where V_0 and V_K are the volume at absolute zero and the critical volume and b is the volume constant; according to Berthelot $V_K/V_0 = 4$; the general mean value seems to lie between 3 and 4. Nernst found for oxygen 2·37, for Cl_4 3·82, *e.g.*, the mean of these and other ratios being 3·47. S. Smiles found for the critical density and the density of the solid d_k/d_f: oxygen 3·56, nitrogen, 3·43, CO_2 3·41, etc., mean 3·49. As regards temperature of boiling-point T_s and critical temperature T_K, the mean ratio T_s/T_K is: Guldberg (65 substances) 0·658, Lorenz (137 substances) 0·638, W. Herz (27 inorganic substances) 0·599. The ratio critical volume/volume at boiling-point seems to have the mean ratio 2·66; the temperature of solidification/critical temperature 0·44, but F. W. Clarke, 1896, and Kurbatow, 1908, found in different series of compounds values up to 2 and 3; the mean ratio melting temperature/boiling temperature is 0·68 (Lorenz, 225 substances) or 0·55 (Herz, 24 elements); the mean ratio volume at boiling-point/volume at melting-point is 1·1748. From these ratios the volume at absolute zero may be deduced as is shown for ethyl alcohol and carbon tetrachloride. In every table the single ratio values for one substance may differ, but the mean values tend to conform. The deviations become larger near absolute zero, and this is to be expected, considering that none of the equations of state pay any heed to the chemical nature and the constitution of the substance. From this point of view substances which obey the rule of corresponding states might be called "ideal physico-chemical" substances.

VI. *Calculation of the Space Occupied by the Molecules in Close Packing.* **R. Lorenz.** (Ibid. 94. 2. pp. 255–264, Feb. 29, 1916.)—The space really occupied by the molecules can be calculated from the mean radius and mean free path, refraction, dielectric constant, etc., and further from the equation of state. If b (van der Waals) be the volume correction $= 4\phi$, where ϕ is the space really occupied, then $V_0/\phi = 4$, and as $V_K/V_0 = 3$, $V_K/\phi = 12$; that is, the volume really occupied by the molecules at absolute zero is 1/12 of the critical volume. Berthelot accepts $V_0/\phi = 4$, but takes $V_K/V_0 = 4$, so that $V_K/\phi = 16$. O. E. Meyer makes $V_0/\phi = 4\sqrt{2} = 5{\cdot}6$, whilst Clausius and G. Jäger assume $V_0/\phi = 2{\cdot}5$, Reinganum 1·77. Guldberg, probably the best work of this kind, finds $V_K/V_0 = 3{\cdot}75$, which lies between van der Waals and Berthelot (3 and 4). The upper limit of space occupation would be $V_0 = \phi$ or $V_0/\phi = 1$; and the value 3 or 4 may be regarded as lower limit. If the molecules be spherical, the closed cubical packing would give $V_0/\phi = 6/\pi = 1{\cdot}91$, and the closer tetrahedral packing $V_0/\phi = 6\pi\sqrt{2} = 1{\cdot}35$. Hence the upper and lower limits would be 1·35 and 4 (or 5·6 Meyer). The question arises, however, whether the ratio, volume occupied by mole-

cules/volume of substance, is really constant for corresponding states; the constancy may exist only for ideal physico-chemical substances.

VII. *Space-filling and Mobility of Organic Ions.* **R. Lorenz** and **L. Posen.** (Zeits. Anorg. Chem. 94. 3. pp. 265–287, March 7, 1916.)—Lorenz showed in 1910 that the diameters of monatomic ions (calculated from their mobility after Stokes-Einstein) are of the order of the size of the atoms. The considerations of space-filling [see preceding paper, VI] are now extended to this deduction. The authors calculate the space-filling by the ions, predetermine the ionic mobility, and compare their mobility values with Bredig's observations. By ionic volume they understand the volume occupied by one gramme-ion; similarly they speak of ionic weight; as the density of the ion is unknown, they proceed indirectly with the aid of cognate compounds and of Kopp's law. For instance, the mobility of the butylammonium-ion is known, further the density of butylamine and of butylammonium chloride; Kopp's law gives the molecular volume from the atomic volume at boiling-point: this is reduced to absolute zero volume by the relation $V_s/V_0 = 1{\cdot}41$. The ionic volumes J_s and J_0 are also referred to boiling-point and absolute zero. Calculations made for 122, mostly monovalent organic ions with kathodes and anions, show that the mobilities fall within the predetermined limits (with few exceptions) so that the ionic space of monovalent ions—including bivalent kathions, not bivalent anions—is not greater than that calculated from the volume of the substance. This conclusion seems incompatible with the assumption that the ions are completely surrounded by a skin of water; if that skin had the thickness of one molecule only, the mobilities should be smaller than those observed. In the mean the experimentally observed mobilities correspond to a space-filling which is in accordance with Reinganum's equation of state. It is finally pointed out that the ionic volume and space-filling should be taken into consideration in comparisons between ionic mobility and constitution. H. B.

987. *Absolute Value of Entropy and Energy.* **E. Ariès.** (Comptes Rendus, 164. pp. 774–776, May 14, 1917.)—The author here proposes to demonstrate the validity of his previous choice of an initial state, common to all substances, from which their entropy and energy may be most conveniently measured. This state was defined as follows:—At a temperature of absolute zero it is condensed to a saturated condition which exerts no pressure; every finite volume-increase at constant temperature only results in the emission of an infinitesimal amount of vapour at the fixed tension ($T = 0$, $p = 0$), *i.e.* its energy and entropy remain zero [Abs. 525 (1917)]. Every diminution of volume obtained by compression at constant temperature entails a growth of pressure and energy from zero to positive values, while the entropy remains zero. In general a body at absolute zero has zero entropy, and zero or positive energy, whatever be the pressure and volume. The author goes on to prove from a study of temperature increments that the entropy of any body defined by its volume and temperature is positive except at absolute zero, when it is zero. Similarly the energy is shown to increase positively. Entropy and energy are thus found never to decrease below the value possessed at the above-defined initial state. The state in which both entropy and energy vanish is that in which, at the absolute zero, no pressure is supported by the body; in consequence the latter is incapable of performing work or parting with energy in the form of heat. H. H. Ho.

988. *The Critical Opalescence.* **E. Cardoso.** (Journ. Chim. Phys. 13. 4. pp. 414–425, Dec. 31, 1915.)—In experiments on the critical state it is observed

that, near the critical temperature, the meniscus disappears and the fluid becomes opalescent like an emulsion. In three series of experiments with CO_2, CO, C_2H_6, CH_4, O, N, etc., made in different tubes of several diameters filled to different degrees and agitated by different means, the author observed the opalescence through a range of only 0·4 deg. C. below the critical temperature, or of 6 deg. C. (3 deg. both below and above that point), or only above the point; the permanent gases, moreover, did not show the phenomenon sometimes. The emulsion theory, proposed by Altschul in 1893 already, seems to be excluded, since the liquid could hardly exist 3 deg. above the critical point. Discussing other suggestions, the author finds the explanation in Smoluchowski's molecular kinetic theory of the opalescence of gases [Abs. 1537 (1908)] which connects the heterogeneity causing the phenomenon with the velocity-distribution of the molecules; as the temperature falls the velocities become more uniform, and local difference in density less marked. Smoluchowski's formula has since been confirmed by observations of K. Onnes and Keesom, and Schidloff [Archives des Sciences 34 (1915)] has deduced it from thermodynamical considerations. The visibility of opalescence may further depend upon the contrast between the fluid and the medium about it. H. B.

989. *Equation of State of Solid Bodies.* **M. B. Weinstein.** (Ann. d. Physik, 52. 5. pp. 506–526, June 7, 1917.)—In this concluding communication the molecular form of the equation of state for solid bodies comes under review. Monatomic substances are first treated, the cases of free oscillation and when impact takes place being dealt with. In this latter case the assumption is made that the virial of the molecule is either quite constant or at the most only dependent on the temperature. Following this comes a discussion of higher atomicities. Grüneisen's work is critically examined. The whole paper is an exhaustive mathematical treatment of the subject and Abs. 516 (1917) should also be consulted. H. H. Ho.

990. *Critical Point, Critical Phenomena, and a few Condensation-constants of Air.* **J. P. Kuenen** and **A. L. Clark.** (K. Akad. Amsterdam, Proc. 19. pp. 1088–1098, 1917. Com. No. 150B. from the Phys. Lab. Leiden.)—The critical temperature and pressure of air have been determined by Olszewski, Wroblewski, and Witowski, but their results do not agree amongst one another as well as might be desired. The main object, therefore, of the present investigation was to obtain reliable values for the critical constants, including the critical density, which involved a detailed study of the condensation-phenomena in the critical region. Wroblewski had noticed that air behaves differently near its critical point from other substances, which behaviour he correctly ascribed to the circumstance of air being a mixture, although the special phenomena which he describes were largely due to insufficient mixing. The authors have therefore repeated the investigation with all those precautions which previous work on mixtures proved to be necessary, and amongst others they have tried to realise "retrograde" condensation which is characteristic of mixtures. So far, an investigation of this sort has never been carried out except at ordinary and higher temperatures, and, as expected, it proved to be beset with great experimental difficulties, which, generally speaking, all originated in the circumstance that the mixture cannot as a whole be cooled down to a low temperature, at least, if the possibility must be left open—and this is an essential condition in the experiments here contemplated—of changing

the volume of the substance gradually. A substance which at the very low temperatures could play the part that is otherwise fulfilled by mercury, viz. that of enclosing a fixed quantity of the substance in a variable volume, is unfortunately not known. It is therefore necessary to compress the mixture in a small tube, which is closed at the bottom and cooled to the low temperature, by means of a piezometer, thus using the same method as followed with pure substances, so that every time a different fraction of the total quantity of substance is present in the observation-tube. With pure substances this does not involve any fundamental difficulty; by measuring the quantity of gas present in the part of the piezometer which is outside the cryostat, the quantity in the observation-tube can at each measurement be derived by subtraction from the total quantity, even when the substance is partly liquefied. With mixtures this is different: in the condensation of a mixture new mixtures are formed each time of different composition; in a series of observations in which the mixture is alternately compressed and expanded the mean composition will even vary from that of the whole, thereby rendering the observations valueless, *e.g.* with air when partly liquefied and re-evaporated, the nitrogen will principally boil away, rendering the mixture richer and richer in oxygen. It was therefore necessary in the experiments to lay down the general rule when partial condensation has once set in not again to increase the volume, and, if the observations have to be repeated or a new series has to be initiated at a different temperature, it is necessary—in order to obtain complete homogeneous mixing—several times in succession to lower the pressure in the apparatus to normal and re-compress to the high pressure. Otherwise in consequence of the very slow diffusion in the capillary connecting tubes with the supply-tube of the piezometer a mixture of higher boiling-point remains behind in the small experimental tube, so that the succeeding observations are bound to be incorrect, and amongst others the condensation even will set in also.

The observation-tube, capillary, and stirrer were the same as used by Crommelin in his investigation of argon. Full experimental details are given in the paper together with the necessary precautions. A distinction has to be made between two different critical points: the plait-point, where the two coexisting phases become identical, and where thus the critical phenomena will be most conspicuous, and, secondly, corresponding to a somewhat higher temperature, the critical point of contact, *i.e.* the limit for the separation into two phases. In the temperature-range between those two points the condensation is "retrograde," in this case of the first kind. The authors have succeeded in confirming these several theoretical conclusions for air, and have thus been able to show, that, at these very low temperatures, the phenomena are no other than what theory leads us to expect. The experiments were far from easy, as the two points lie very close together, which is connected with the circumstance that the condensation-loop in the p — T figure turned out to be comparatively narrow. The plait-point was found at $t = -140°{\cdot}73$, $p = 37{\cdot}25$ atmos. the critical point of contact at $t = -140°{\cdot}63$, $p = 37{\cdot}17$ atmos. A full description is given of the extreme sensitiveness of the substance in the critical region to changes of temperature and pressure. More than once a blue opalescence was noticed, when the pressure was somewhat lower than that required to produce the cloudy condensation, and sometimes persisted during the stirring. By a rapid movement of the stirrer the opalescence could as a rule be changed into a mist. Pure oxygen and argon do not seem to show opalescence.

Tables and curves accompany the paper. H. H. Ho.

SOUND.

991. *Tonodeik or Pitch Indicator.* **L. E. Dodd.** (Scientific American, 115. pp. 410 and 422–423, Nov. 4, 1916.)—A semi-popular article on various recorders or indicators of pitch concluding with the *tonodeik* which is a modification of Seashore's tonoscope. These instruments on the stroboscopic principle show (to a few vibrations per sec.) the frequency of a note sung by a performer when practising, and thus enable him to train the voice without any one to listen. The exact details of the apparatus are not explained.
E. H. B.

992. *Binaural Beats.* **G. W. Stewart.** (Phys. Rev. 9. pp. 502–508, 509–513, and 514–528, June, 1917.)—A series of papers presenting respectively an introduction, a treatment of the secondary intensity maxima, and a theory of binaural beats.

When two tones of almost the same pitch are presented one to each ear, there appears an intensity maximum with 0° difference in phase, and secondary maxima at phase differences of $180° - \delta$ and $180° + \delta$. The secondary maxima are perceived clearly only when the beat-period exceeds one or two secs. They seem to have an origin somewhat different from that of the zero-phase maximum. The value of δ/π varies from 0·17 (for frequencies of 42 per sec.) to 0·32 (for frequencies of 469 per sec.). The relation, however, is not linear. Further, the values of δ observed vary with the physical state of the observer. It is pointed out that much of what is known on the subject, and often overlooked, is given in the excellent works of P. Rostosky ("Philosophic Studies," 1902, and "Beiträge zur Psychologie und Philosophie," 1905). E. H. B.

993. *Analogue to Open Pipes.* **P. Selényi.** (Phys. Zeits. 18. pp. 133–134, April 1, 1917.)—As a vibrating system analogous to an open pipe, a stretched string is here considered, divided into three portions. The first portion, of considerable density, represents the air in the pipe; the third portion, of much less density, represents the open air; while the second, or intermediate, of graduated density, represents the special region which gives the correction at the open end. This analogous system of strings is then treated mathematically. E. H. B.

994. *Influence of Wind on Conditions of Audibility.* **A. Perot.** (Comptes Rendus, 163. pp. 272–273, Sept. 11, 1916.)—Discusses with diagrams the course of sound waves with and against the wind, which latter is steady near the ground and for some height, and then changes (through a certain further height) down to a dead calm. E. H. B.

995. *Musical Sounds and their Analysis.* **D. C. Miller.** (J. Phys. Chem. 21. pp. 338–342. April, 1917. Review.)—This book is a development of a series of eight lectures on sound analysis delivered at the Lowell Institute in 1914, and is noteworthy for the wealth of illustrative experiments described, the most important being those by which were obtained the graphs of the various tone qualities by means of the *phonodeik*. [See Abs. 991 (1917).] E. H. B.

996. *Resonance Theory of Hearing.* **E. Budde.** (Phys. Zeits. 18. pp. 225–236, May 15, and pp. 249–260, June 1, 1917.)—A review of the knowledge obtained and views held on this subject from Helmholtz to recent times. The first division deals with the perception of sustained simple tones; the second treats of intermittent tones, phase-change tones, reflection-tones, and combination tones. There is also a supplement on damping. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

997. *Mass of Electric Carrier in Copper, Silver, and Aluminium.* **R. C. Tolman** and **T. D. Stewart.** (Phys. Rev. 9. pp. 164–167, Feb. 1917.)—In a previous article some experiments were described in which a coil of copper wire was rotated about its axis at a high speed, and then suddenly brought to rest, the ends of the coil being connected with a sensitive ballistic galvanometer, which permitted a measurement of the pulse of current which was produced at the instant of stopping by the tendency of the electrons to continue in motion. These experiments have been continued with new windings of copper, also with others of silver and of aluminium. For all three metals the effective mass of the carrier comes out somewhat larger than the accepted value for the mass of a slow-moving electron in free space. The latter is about 1/1845 of the hydrogen atom, whereas the authors find the carriers to be 1/1660 in Cu, 1/1590 in Al, and 1/1540 in Ag. [See Abs. 1266 (1916).] E. H. B.

998. *Electron Equations in Einstein's Gravitation Field.* **J. Tresling.** (K. Akad. Amsterdam, Proc. 19. 6. pp. 892–896, 1917.)—Hilbert [Gesell. Wiss. Göttingen, Nachr. p. 395, 1915] has derived the fundamental equations of an electromagnetic field in space free from electrons from a variation principle, in which the principal function is considered as depending on a four-dimensional vector-potential and its differential coefficients with respect to the four coordinates. The author shows that by adding to Hilbert's principal function a term representing the effect of the electrons, and proceeding on the lines followed by Lorentz [Abs. 720 (1917)], Hilbert's method may be extended to a space containing electrons. G. W. DE T.

999. *Frictional Electricity.* **N. R. French.** (Phys. Rev. 9. pp. 151–163, Feb., 1917.)—An experimental research which may be summarised as follows:—(1) Jones's theory as to the cause of the reversal in sign of the charge produced on a metal specimen has been proved incorrect. (2) For each of the two alloys examined the max. charge was not the average of the max. charges of the constituent metals, being, in fact, no larger than that from the constituent giving the smaller charge. (3) A relationship between the charge and the absolute humidity, for a definite amount of frictional work, has apparently been found to exist. (4) The decrease in the charge produced by a definite amount of work on a specimen which has been allowed to remain in contact with the atmosphere after previous rubbing, has been shown to be caused by contact with a mixture of air and water-vapour, and not by an elastic recovery. (5) To explain the facts, a theory, based upon the adsorption of air by the surface of the metal, has been proposed. E. H. B.

DISCHARGE AND OSCILLATIONS.

1000. *Complete Photoelectric Emission from Na-K Alloy.* **W. Wilson.** (Roy. Soc., Proc. 93. pp. 359–372, July 2, 1917.)—Shows that the law governing the variation of the complete photoelectric emission from the alloy of K and Na with the temperature of the source of radiation is well expressed by O. W. Richardson's formula for the temperature variation of the thermionic emission from metals. This formula is $c = AT^{\lambda}e^{-\phi/\kappa T}$, where ϕ is the work

done in removing an electron from a hot body, κ is the gas constant, and A is a quantity characteristic of the substance, and independent of the absolute temperature T. The alloy consisted of K and Na in atomic proportions, and 3 cm. above it a horizontal Pt wire traversed by a current and nearly enclosed in a silver sleeve formed the radiator. The temperature of the radiator was controlled by placing a small crystal of some substance of known melting-point (naphthalene 80° C., $PbCl_2$ 447° C., NaCl 801° C., K_2SO_4 1070° C.) on the wire and increasing the current until the crystal melted. The photoelectric currents were measured either by galvanometer or electrometer.

The photoelectric emission is most probably a definite proportion of the thermionic emission. Hence the relation found is what might be expected.

E. E. F.

1001. *Loss in Energy of Wehnelt Kathodes by Electron Emission.* **W. Wilson.** (Nat. Acad. Sci., Proc. 3. pp. 426–427, June, 1917.)—The thermionic current from a hot kathode is given by the equation $i = a\theta^{1/2}e^{-b/\theta}$, where θ is the absolute temperature, and a and b are constants. Richardson and Cooke, and later Lester, have obtained values for tungsten which are in very good agreement with the values of b obtained by Langmuir and K. K. Smith. On the other hand, Wehnelt and Jentsch, Schneider, Wehnelt and Liebreich, and Richardson and Cooke have all found that for lime-covered kathodes either the effect is so small in comparison with other energy changes as to be completely masked, or that there is no correspondence between the two quantities. Since these experiments suggest that the mechanism of thermionic emission from Wehnelt kathodes is different from that for pure metals, further experiments were made by the author to determine whether consistent results could be obtained by using more stable kathodes. If W is the work done by an electron in leaving the surface of a hot body, $W = bR$, where R is the gas constant for one molecule. If it is assumed that the work done by the electron is that done by moving through a double layer of strength ϕ we have $W = \phi e$, and $\phi = bR/e$. The method of Richardson and Cooke was used for the direct determination of ϕ. The constant b was determined in the usual manner, the thermionic current being measured with the kathode at different temperatures, which were obtained by means of an optical pyrometer of the Holborn and Kurlbaum type. The following results were obtained :—

Filament.	θ.	bR/e (volts).	ϕ (volts).
1	27,200	2·34	2·39
2	30,100	2·59	2·54
3	23,500	2·02	1·97
4	25,200	2·16	2·28
5	38,200	3·28	3·22
6	40,600	3·49	3·45

Filaments 1 and 2 were coated with BaO 50 %, SrO 25 %, CaO 25 % ; filaments 3 and 4 with BaO 50 %, SrO 50 % ; and filaments 5 and 6 with CaO alone. It appears that for Wehnelt kathodes the values of ϕ and bR/e show a good correspondence. This is a strong point in favour of the view that the emission of electrons from Wehnelt kathodes is due to a similar mechanism to that causing the emission from heated pure metals. It is also a further proof of the substantial correctness of Richardson's hypothesis to account for the emission of electrons by hot bodies.

A. W.

1002. *Discharge Potential of Ions on Heated Electrodes.* I. **J. C. Ghosh.** (J. Phys. Chem. 21. pp. 426–432, May, 1917.)—A method is described of measuring the discharge potentials at various temperatures of ions such as SO_4, NO_3. A Pt wire is immersed in a dilute salt solution and its temperature raised by an electric current. On this wire is discharged the anion of the salt by another current, passing through a second circuit which includes the mid-point of the wire, electrolyte, electrode in the solution, milliammeter and a variable e.m.f.

Figures are given showing the variation of discharge potentials of SO_4, NO_3, Cl, and Br ions respectively with the strength of the current, when the electrolytes are pure salts of Cu. When the temperature of the wire is 30° C., the current-potential curve is almost vertical for small currents, tending to become horizontal for greater currents. The decomposition potentials of SO_4, NO_3, and Cl on the Pt wire at 30° C. are about 1·5, 1·45, and 1·6 volts. The curves are quite different when the Pt wire is at 96° C. The discharge potential is almost independent of the current strength, so the effect of raising the temperature of the wire is to make the discharge of such ions resemble that of reversible ions like those of Cu or Zn. The decomposition potentials for NO_3, Cl, and Br ions at 96° C. are 0·78, 0·75, and 0·45 volts respectively. It is apparent that not only has the phenomenon of overvoltage disappeared at 96° but that the decomposition potentials of Cl and Br ions are less than their respective normal electrode potentials. Attempts were made to find the discharge potential of I-ions by using a cell $Cd/CdI_2/Pt$ wire (anode). The curve is not at all similar to those for Cl, etc., which is perhaps due to complex electrolytic dissociation of the salt CdI_2. T. H.

1003. *Motion of Ions and Electrons through Gases.* **E. M. Wellisch.** (Phil. Mag. 34. pp. 33–66, July, 1917. Am. J. Sci. 44. pp. 1–32, July, 1917.)—In determining the mobility (k) of ions as a function of the pressure (p) of the gas, the author has shown [Abs. 1099 (1915)] that, in the case of air, $pk = \text{const.}$ down to 0·05 mm. for the positive ion, and that the negative carriers consist of two kinds, electrons and ions, the former coming more and more into evidence as the pressure of gas is reduced. The law $pk = \text{const.}$ was verified for the negative ion down to 0·15 mm. and the ion, therefore, is unaltered down to this pressure. The electrons move freely through the gas without attaching themselves to molecules. No indication of any intermediate stage in the nature of the negative carriers was detected. These results have been extended in the present investigation to other gases, notably CO_2 and hydrogen. For these gases the electrons are relatively more numerous than in air at corresponding pressure. A trace of impurity is found to be especially effective in reducing the number of free electrons when the gas is at a relatively high pressure; at low pressure the effect is often inconsiderable. In most cases a velocity greater than that arising from thermal agitation at ordinary temperatures appears to be necessary to enable the electron to effect a permanent union with an uncharged molecule of gas or impurity.

For the vapour of petroleum ether, whose molecules contain only atoms of carbon and hydrogen, the negative carriers appear to consist practically entirely of free electrons, but a trace of impurity is sufficient to effect the production of negative ions.

A brief investigation is made of the motion of free electrons through CO_2. The results do not indicate that the velocity of the electron is proportional to the applied force, but suggest that the electron may traverse a considerable distance with accelerated motion before its terminal velocity is acquired.

The method was employed to determine the mobility in a few vapours, and the results are compared with previous determinations.

A long discussion is given of the bearing of the results on ionic theory. Ions and electrons are regarded as passing independently through the gas unchanged in nature. The transition from conduction by ions in a gas at high pressure to conduction by electrons at low pressures is explained as due to an increase in the number of free electrons relative to the number of ions, without any change in the nature of either carrier. From this point of view the permanent gases must contain free electrons, theoretically at all pressures. The inert gases and hydrogen are regarded as exceptional, not in their power of containing free electrons, but by their reluctance to form negative ions, *i.e.* by the large proportion of electrons to ions.

The experiments on petroleum ether suggest that the negative ions in CO, CO_2, etc., are due almost entirely to the presence of oxygen atoms. Franck arranged gases in the following order of increasing electron affinity: helium, argon, nitrogen, hydrogen, oxygen, nitric oxide, chlorine. If this series is regarded as affording a relative idea of the proportion of electrons and ions which results from ionisation it seems probable that in order to supply an appreciable number of ions the molecules of a gas must contain oxygen, chlorine, or (by analogy) other electro-negative atoms, *e.g.* bromine or iodine.

A theory is given to account for the effect of a trace of oxygen in reducing the number of free electrons in hydrogen or an inert gas.

The nature of the gas ion is discussed. Considerations given indicate that the notion of the ion as a cluster is unnecessary. Also it is difficult to reconcile the fact that electrons are here shown to pass unencumbered through gases at considerable pressures with the cluster theory. Further direct evidence in favour of the single molecule theory is quoted.

Regarding the ion as consisting of a single charged molecule the difference in mobility of positive and negative ions must be ascribed to a difference in the attractive forces between each kind of ion and the uncharged molecules. It seems logical to extend the conception of Franck and Hertz, of electrons possessing different degrees of elasticity when in collision with molecules of different gases, so as to apply to the collisions between ions and neutral molecules. The problem is discussed from this point of view. T. H.

1004. *Polarisation at the Kathode in a Highly Ionised Gas.* **C. A. Skinner.** (Phys. Rev. 9. pp. 97–112, Feb., 1917.)—The author argues that Aston's experiments [Abs. 228, 487 (1913)] indicating that there is no p.d. between a kathode and the conducting gas adjacent to it, were not made under normal glow-current conditions as was assumed.

Experiments are described in which a discharge is obtained in hydrogen. In the negative glow two small transverse electrodes are placed with their planes parallel to the current through the discharge, forming, with the gas of the negative glow, a battery, galvanometer and an external resistance, a circuit in which the e.m.f. (E) and current (c) are measurable. The transverse current is small compared with the ionising current through the discharge, so that, as there is no appreciable p.d. between the electrode acting as anode in the negative glow and the gas, the resistance (R) between the transverse electrodes is assumed to be concentrated between the electrode acting as kathode and the gas. Then $R = E/c - r$, where r is the external resistance in the circuit. The measurements were made using electrodes of Al and Pt. The value of R varies with the transverse current, and shows a minimum value for small values of c and a maximum for high values, varying

from $1{\cdot}8 \times 10^5$ to $7{\cdot}7 \times 10^5$ ohms. Thus a kathode placed in the highly ionised negative glow, where a polarisation p.d. would be least expected, shows that it is present in large magnitude. It is found that with a constant polarisation p.d. at the kathode, the apparent kathode resistance per cm.^{3} is very nearly inversely proportional to the ionising current through the main discharge and very nearly independent of the gas pressure, from which it is concluded that the apparent kathode resistance is simply inversely proportional to the density of positive ions in the gas round the kathode. This relation is employed to calculate the apparent resistance of the transverse kathode with current density equal to the "normal" current density at the main kathode in the discharge. The calculated value is the same as that obtained by the wire-probe method at the main kathode and therefore proves the reliability of wire-probe measurements in the Crookes dark space.

Between two fairly well separated values of the polarisation p.d. the apparent kathode resistance is, for constant ionising current, practically proportional to the current density. The deviation of the resistance curve from the straight line at the higher potentials probably arises from the extra ionisation produced by the electrons escaping from the transverse kathode. For the straight part of the curve the author formulates a tentative law that $V = A(j/n)^2$, where V is the polarisation p.d., A is constant, j the current density at the kathode, and n the number of positive ions per unit volume of gas round the kathode. T. H.

1005. *Electrode Polarisation in Gases.* **C. A. Skinner.** (Phys. Rev. 9. pp. 314–324, April, 1917.)—Recent work by the author [see preceding Abs.] shows that, as indicated by wire-probe measurements, there exists in general a polarisation p.d. wherever a current is transmitted from gas to electrode by ionic carriers. This applies to the anode as well as kathode, but when the anode is in the negative glow the polarisation p.d. practically vanishes, presumably because the current is transmitted by free electrons. Outside the negative glow the anode polarisation is about 20 volts. Lacking any free positive electrons, there is no part of the glow discharge where the kathode polarisation vanishes. Only when the current is made up of free electrons—and possibly ions leaving the electrodes instead of discharging into them—can we assume that no polarisation exists. Such a condition obtains approximately at the kathode in the ordinary arc, at both electrodes in the mercury arc and at a Wehnelt kathode. Important errors are made by ignoring the existence of a polarisation, especially at the kathode, *e.g.* by supposing a potential to be impressed upon a conducting gas by two metal electrodes charged to a definite p.d.

The author proceeds to give a simple mathematical theory, with experimental applications, of this electrode polarisation as arising from an elastic rebound of the discharging ions from the electrode. The polarisation p.d. arises from the consequent accumulation of the discharging ions at the electrode surface. The theory leads to the expression $V = A(j/n)^2$ for the straight portion of the resistance curves previously found, and the deviation from this when V is below about 10 volts is worked out by taking into account the temperature velocity of the discharging ions. T. H.

1006. *Ionisation in a Magnetic Field.* **A. Righi.** (R. Accad. Sci. Bologna, Mem. 4. pp. 1–20, 1916–1917. N. Cimento, 12. pp. 241–266, Dec., 1916.)—After clearing away preliminary difficulties and dealing with causes of error, the author demonstrates his "magneto-ionisation"; *i.e.* that the magnetic

field tends so to orientate atoms as to reduce the average minimum energy which an ion must have in order to produce ionisation upon its impact against an atom. A. D.

1007. *Figures Produced on Photographic Plates by Electric Discharges.* **U. Yoshida.** (Kyōtō Coll. Sci., Mem. 2. pp. 105–116, March, 1917.)—Various figures are produced under different conditions; beautiful reproductions from the developed plates are included. The photographic effect on the plate is due to the luminosity of the discharge; and this follows the paths of ionisation of molecules of gas. Tracing out these paths accounts for the peculiarities of form of the figures produced. A. D.

1008. *Spark Discharge in Compressed Gases.* **C. E. Guye and C. Stancescu.** (Archives des Sciences, 43. pp. 131–160, Feb., 1917.)—According to Paschen's law the spark-potential V is connected with the gas pressure p and the distance between the electrodes d by the relation $V = f(pd)$ at constant temperature. The law may be generalised to take account of temperature; it then takes the form $V = \phi(pd/T)$, where T is the absolute temperature of the gas. Divergencies from the latter formula are to be expected when the condition of the gas is such that the law of Boyle-Mariotte-Gay Lussac, ceases to hold. The authors have investigated the spark-potential in compressed CO_2 for five sparking distances, viz. 0·34, 0·54, 0·80, 1·1, and 2·24 mm. The max. p.d. at their disposal was 40,000 volts derived from a Wimshurst machine. In the case of the short sparks (0·34 and 0·54 mm.) they were able to work at pressures of about 50 atmos., but in the case of the longer sparks they were limited to about 13 atmos. The graphs V — p.d. indicate that the various observations cannot be grouped on a single curve, except for regions where the gas pressures are small, *i.e.* where the perfect-gas equation is approximately satisfied. If, however, V is plotted against md, m being the mass of gas contained in unit volume, the observations fall on a single curve. The authors conclude that in the form $V = F(md)$, Paschen's law holds over a considerable range for a gas which departs considerably from the perfect-gas law. I. W.

1009. *The Mode of Operation of Crystal Detectors.* **B. Thieme.** (Phys. Zeits. 17. pp. 615–618, Dec. 15, 1916.)—The author in first referring to Fischer and Baerwind's work on the silicon detector [Abs. 71 (1917)], dissents from their view as to the action being of a thermoelectric nature. He also does not believe in the earlier explanation of a point-and-plate action of the contact, since it is, in any event, rather a case of opposed two plates (surfaces) of small mutual contact surface. The explanation of a greater current density at the point electrode could only apply if a liquid layer were interposed and no actual contact occurred.

What the author finds of importance is, the angle at which the current enters, with respect to the crystal axis; in other words, the angle at which the entering electrons come into action, with respect to the fundamental electric vibration-plane. He then deals with the question under the headings: Symmetrical and unsymmetrical crystal forms, moisture films, and observations; all at too great length for brief abstraction. His observations are directed to obtaining support for his moisture-film theory of the detector's operation, and he claims to have obtained remarkable results with mixed crystals—for instance, of Cu and Ni—further details as to which are withheld. L. H. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1010. *Electrical Resistance of Metals under Pressure.* **P. W. Bridgman** (Am. Acad., Proc. 52. pp. 573–646, Feb., 1917.)—In this elaborate experimental paper are described the tests for the changes of resistance between 0° and 100° C. over a pressure-range from 0 to 12,000 kg. of the following 22 metals:—Indium, tin, thallium, cadmium, lead, zinc, magnesium, aluminium, silver, gold, copper, nickel, cobalt, iron, palladium, platinum, molybdenum, tantalum, tungsten, antimony, tellurium, bismuth.

Three of the metals are abnormal; Bi and Sb both have a positive pressure coefficient, and the pressure coefficient of Te has an abnormally large negative value. The other 19 metals have minute differences in their individual behaviour, but in broad outline their behaviours are alike. The pressure coefficient changes very little with temperature, and therefore also the average temperature coefficient changes very little with pressure; this holds over a range of pressure great enough in many cases to compress the metal to less than its volume at 0° abs. under atmospheric pressure. The instantaneous pressure coefficient of all the normal metals, on the other hand, decreases markedly with increasing pressure. By far the larger number of the normal metals show a decreased relative curvature in the resistance-pressure curve at the higher temperature.

It is shown that none of the hitherto-proposed theories can account satisfactorily for all these facts. The recent attempt by Grüneisen, however, must be recognised as a promising beginning. [See next Abs.] E. H. B.

1011. *Theoretical Considerations on the Nature of Metallic Resistance, with Special Regard to Pressure Effects.* **P. W. Bridgman.** (Phys. Rev. 9. pp. 269–289, April, 1917. Nat. Acad. Sci., Proc. 3. pp. 10–12, Jan., 1917.)—The author considers the most important result of this paper is the observation that the variations of resistance of a normal solid metal are preeminently concerned with one factor only, the average amplitude of vibration of the atoms, irrespective of whether the change of amplitude is brought about by a change of pressure or of temperature. The proportional change of resistance is approximately twice the proportional change of amplitude. This suggests that a successful theory of metallic conduction must discard the old viewpoint, which explained resistance in terms of the properties of an assemblage of electrons little affected by the inert framework of atoms, and substitute an explanation in terms of the properties of the atomic framework. There are several possible ways of giving such an explanation, of different physical complexions, all of them suggesting an intimate connection between resistance and amplitude. The view here adopted is that apparently best adapted to harmonise the entire range of facts. This view is that the electrons normally pass freely from atom to atom, but if the atoms are separated beyond a critical distance, as by temperature agitation, gaps appear between the atoms which offer resistance. The resistance at ordinary temperatures is proportional to the number of gaps, and it is not unplausible to expect the change in the number of gaps to be twice the proportional change in the amplitude. At higher temperatures, however, that is large volumes, as in liquid metals, the passage of electrons from atom to atom is on the average difficult, but is facilitated by a collision of unusual violence. An increasing amplitude acts in opposite ways, therefore, at large and at small volumes. Under actual conditions there must be a combination of these two effects in varying proportions. In the body of the paper it is shown in

detail how the play against each other of these two different effects offers a explanation of the most important features of the behaviour of both norma and abnormal metals.

Consistency with the author's view seems to him to demand a distortio of the atom under pressure. [See preceding Abs.] E. H. B

1012. *Electrical Resistance of Thin Films of Metal.* **S. Weber** and **E. Oosterhuis.** (K. Akad. Amsterdam, Proc. 19. pp. 597–608, 1917.)—Th authors review briefly the previous work of Longden [Abs. 2214 (1900)] Patterson, and others. In all these investigations the films used had bee formed either by chemical methods or by means of kathodic discharg Measurements on the electrical resistance of metallic films formed b *evaporation* had not been made. However, films formed by the last-mentione process have the following advantages: (1) The film is easily obtaine perfectly uniform. (2) According to the kinetic theory it must be assume that a metal evaporates as molecules, not as complex groups of molecules this assumption is in accordance with some of Knudsen's measurement (3) The film is formed in a high vacuum, so that there can be no danger o any reaction, chemical or otherwise with gases. For the reasons just give the authors have investigated the resistance of thin films formed by evapora tion. They find that these films possess the additional advantage that the time-change of resistance is smaller than that of films formed by chemica deposition or kathodic discharge, which circumstance is naturally ver favourable to obtaining constant results. The experiments were made wit thin films of Pt, W, and Ag. The Pt was Heræus' chemically-pure P ($\alpha = 0{\cdot}003905$); the tungsten and silver were very pure. The films wer formed on the inner wall of a cylindrical glass tube about 36 mm. wid Inside, about half-way up the tube, two silvered rings were formed 16 mm apart; from each of the silvered rings two Pt wires, sealed through the glass led to the outside. By measuring the resistance between the two wires con nected to the same ring, the contact between the latter and the film could b tested. The wire which evaporated was of hair-pin form, with legs a few mm. apart, and having its ends connected to two terminals at the upper en of the cylinder; the part of the hair-pin which was opposite the rings showe a perfectly uniform glow. To the lower end of the glass cylinder a lam was sealed in which a tungsten spiral was enclosed. The whole wa thoroughly evacuated, while at the same time the glass wall was heated an the hair-pin was made to glow, in order to free both from gases as com pletely as possible. After the tube was sealed off from the pump, th tungsten spiral was kept at a very high temperature for some time, by whic process the last remnants of gas were removed and a very high vacuum wa obtained. The hair-pin wire under examination was then made to glow at constant temperature, $Vi^{1/3}$ being kept constant, where V = p.d. between th ends of the wire and i = current. The thickness of the films was calculate from the mass of metal deposited per cm.^{2} of the glass wall, assuming tha the ordinary value of the density can be used. For Pt and W the velocity o evaporation is known as a function of the temperature; in the case of Ag th total quantity evaporated was determined directly by weighing. In makin the resistance measurements the wire was heated at constant temperatur during a given time, the resistance of the film was then measured, the wir was heated again for a given time, and the resistance of the film which ha now increased in thickness was measured. Proceeding in this manne possible changes of the resistance of the films with time are eliminate

seeing that the thickness of the film is made greater by evaporation, as soon as the resistance measurement is finished, and that the change of the resistance in the course of an experiment was inappreciable. The measurements were made at a temperature of 22° C. The conduction of the Pt film begins to be measurable at a thickness of 1·645 $\mu\mu$; a black deposit is then already clearly visible on the glass wall; the rapid increase of resistivity begins at about 7 $\mu\mu$. With W a perceptible conduction begins to appear at 0·5 $\mu\mu$; the strong increase of resistivity begins at about 2·5 $\mu\mu$. For Ag the corresponding thicknesses were 6·5 $\mu\mu$ and 25 $\mu\mu$. Comparing the results obtained by the authors with Pogany's measurements on Pt and Ag films, formed by kathodic discharge, a tolerable agreement exists as regards the thickness at which the layers first begin to conduct. Assuming, as the authors do—at least for Pt—that conduction in a film formed by kathodic discharge first begins when a sufficient number of molecules have been deposited for a continuous layer to be formed on the wall, the agreement in question would show, that with kathodic discharge, films consisting of molecules and not of complexes may also be formed. If we assume the dimensions of metallic molecules to be of the same order of magnitude as the value given for gaseous molecules, *i.e.* about 5×10^{-8} cm., the results show that for conduction a film is needed two or three molecules thick with Pt, one molecule with W, and twelve molecules with Ag. For comparatively thick films the resistance-change on heating is not very great, and after some time the resistance reaches a constant value; it was thus possible for Pt films of about 126 $\mu\mu$ to obtain definite results for the temperature coefficient of resistance; for two different specimens: within the temperature-range 22° to 140° C., values of 0·00276 and 0·00244 respectively were found. The Pt wire from which the films were formed by evaporation had a temperature coefficient of 0·003905. For very thin films at room temperature the resistance-change with time was very small; when these very thin films were heated to 130° C. the resistance increased rapidly and ultimately became infinite, but the black appearance of the film did not change. If the heating is stopped before the resistance has become infinite, the resistance after cooling is higher and apparently Ohm's law is not satisfied. The authors also observed the following phenomena with very thin films: A Pt film, about 3·5 $\mu\mu$ thick, gave on repeated measurement a constant value for the resistance of $3{\cdot}72 \times 10^4$ ohms; after the admission of air the resistance assumed a constant value of $3{\cdot}15 \times 10^4$ ohms. This observation perhaps indicates that the presence of air or, possibly, of moisture might play a part in the change of resistance of thin films with the time. I. W.

1013. *Electrical Conductivity of Air and of Mica.* **E. Branly.** (Comptes Rendus, 163. pp. 943–948, Dec. 26, 1916. Rev. Gen. d'Él. 1. pp. 283–285, Feb. 24, 1917.)—While studying the mode of action of wireless detectors the author has investigated the resistance of small piles consisting of a number of thin plates of very transparent white mica. A thickness of mica greater than 0·006 or 0·007 mm. interposed between two metallic discs transmitted no current when connected to 5 to 10 accumulator cells in series; but for thinner sheets, particularly for those thinner than 0·003 mm., the e.m.f. applied must be considerably reduced. Some of these very thin sheets, when submitted to a minute examination, after having been found to be conducting for a p.d. equal to or less than 1 volt, were found to have, on their surfaces, circular holes of very small diameter. The question naturally arises whether these holes existed before the passage of the current and whether their presence tended to produce a transmission of current without

rupture of the substance. The author had already investigated the behaviour of little cells of air, 4, 3, 2, and 1 mm. in diam., enclosed between two metallic discs separated by laminæ of perforated mica, and he had shown that the imprisoned gaseous layers were susceptible of becoming progressively and freely conducting. As a result of these experiments he decided to diminish the diam. of the air cells down to a small fraction of a mm. in order to see whether a reduction in the diam. and thickness of the air cell did not tend to favour electrical conductivity by diminishing the extent of the excursions of the molecules. For this purpose holes of 0·5, 0·3, and 0·2 mm. diam. were pierced in mica plates, the thickness of which was usually less than 0·004 mm. Since, for the same thickness and under the same applied e.m.f., the lamina pierced with small holes became conducting much more easily than the unpierced laminæ, it was, perhaps, natural to suppose that, in the case of continuous sheets, the currents were transmitted only through small holes occupied by gas. In any case, whatever may be the ultimate explanation, the author describes very fully in this paper his exact mode of procedure. The circuit consisted of (1) a source of e.m.f., (2) two metallic discs between which the thin plate of mica, pierced or unpierced, was placed, and (3) a suitable galvanometer. All the discs referred to in (2) were held between the piston and the platform of a special pump under a perfectly definite and readily reproducible pressure. The discs employed were those used in 1915, but for convenience in cutting, polishing, etc., the diams. have been reduced to 18, 15, 12, and 10 mm. The following are typical observations :—I. Discs of Pt and Ag separated by a mica plate, pierced with a central hole 0·2 mm. in diameter ; applied e.m.f., 1 volt : at the end of 1 hour from the time of closing the circuit there was a large galvanometer deflection, the Ag plate being connected to the positive pole of the cell ; when the current was reversed the deflection was zero ; on re-applying the e.m.f. in the original sense the larger deflection was again obtained ; these alternations could be produced successively after periods of rest ; the large deflection is sometimes reached rapidly and at other times progressively in jerks. In several cases the deflections were not obtained until the e.m.f. had been applied for 10 or 24 hours ; in many analogous cases the difference was not so absolute as in the above ; frequently also there was no difference ; for some conditions which appeared to differ little, if at all, from the preceding there was no deflection in either direction ; wherever there was a deviation the sensibility to shock and to a distant spark was always observed. II. Discs of Pt separated by a mica disc pierced centrally with 6 small holes each 0·3 mm. in diameter ; applied e.m.f. 0·04 volt : when the e.m.f. had been applied for 1½ hours a conductivity, which was almost perfect [complète] was established, and this persisted, even when the e.m.f. was reduced to 0·004 volt, almost as strong as if the mica were suppressed. With the same discs and a different sheet of mica, pierced like the other, conductivity was established without shock. **I. W.**

1014. *Electric Properties of Rare Metals.* **C. Benedicks.** (Internat. Zeits. Metallgraphie, 7. pp. 225–238, 1915.)—Most of the metals examined being specimens of small weight (about 10 gm.), presented to Upsala University, the 0·46 gm. of germanium by its discoverer, Clemens Winkler, analyses could not be made, and a method, to be described elsewhere, was developed after Gallander, for deducing the resistance from measurements of potential and current between point electrodes touching a piece of the metal, *e.g.* 1·7 mm. in thickness. Cerium (big lump of 67 gm.) gave a specific resistance of 78 (value probably too high, owing to fissures in the metal) ; praseodymium, 88 ; neodymium, 79 ; ruthenium, 14·4 (also too high,

the metal containing bubbles); uranium, 62 (too high, owing to presence of carbide); uranium certainly conducts better than bismuth. The resistance of germanium (Ge) was found to lie between that of Si and of Sn. The highest thermoelectric force so far observed is that of Si, $a = -680$ microvolts against copper (E. Baerwind, Dissertation, Berlin, 1914). Si gives sometimes a positive a, however, which Baerwind ascribed to presence of oxides, whilst the author and O. Tenow find that rapid cooling leads to a negative a, and slow cooling to a positive a, there being probably allotropic modifications of Si. Grey tin, obtained by very slow cooling of white tin, was thermoelectrically strongly positive to copper, white tin being weakly negative. Germanium gave the highest force next to Si, $a = -380 \pm 40$; this Ge was rapidly cooled. To test the rectifying power of Ge, the specimen was embedded in Wood's alloy and then pressed against a plate or point of Pt or Cu in a 2-volt circuit; the current passed much more readily from Pt to Ge than the other way, the ratio being 14 : 1, and about 5 : 1 for Cu and Ge; with Si Baerwind found a rectifying ratio of 28 : 1. There was also rectification between a point and a plate of the same element, either Ge or Si, the ratio being 4 : 1 for Ge and less at greater contact pressure. The direction of the rectification was contrary to the rule of Tissot [Abs. 1015B (1908); as to Fischer and Baerwind, see Abs. 1016 (1917)]. H. B.

1015. *Electrical Conductivities of Dilute Amalgams.* **T. B. Hine.** (Am. Chem. Soc. J. 39. pp. 882–895, May, 1917.)—The author describes the preparation of sodium, potassium, and lithium amalgams containing one atom per cent. or less of the dissolved metals. Tables and curves of conductivity are given, and the apparatus and method of measurement are described in detail. The author hopes that the results may presently assist in throwing further light upon the mechanism of electric conduction and in leading to a more precise conception of what is meant by a free electron.

G. W. DE T.

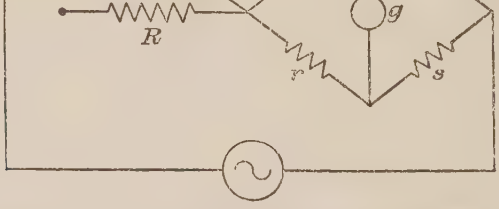
1016. *Silicon and its Position in the Thermoelectric Series.* II. **F. Fischer** and **E. Baerwind.** (Zeits. Anorg. Chem. 97. 1. pp. 56–73, Sept. 12, 1916).—In 1913 the authors and R. Lepsius [Abs. 1341 (1913)] observed that samples of silicon from different sources differed thermoelectrically, some being very strongly positive, others negative; the difference seemed to be due to the presence of oxide (or more oxide) in the negative variety. Attempts to confirm this explanation by analysis did not lead to any conclusive result. Though compact Si may be heated to 1100° without increasing in weight (it becomes iridescent, however), the finely-divided Si oxidises distinctly at 210°, and when the silicon was ground in an agate (or a silicon) mortar for dissolution in caustic potash, there was appreciable oxidation, probably because the grinding was constantly exposing fresh hot surfaces of Si to the oxygen. The Si was, therefore, dissolved in metals. Crystallised from Al, in which it is readily soluble, the Si was always highly positive (+ 509 microvolts per deg.) no matter whether it had originally been positive or negative; when the metal was cooled very quickly, the Si crystals were very small, and the thermoelectric determination was difficult, but the Si was positive. This silicon could hardly contain any oxide, which would have been reduced by the Al, but it did contain some Al. Crystallised from silver, in which it is less soluble, and from tin, in which it is still less soluble, the Si was always negative; these metals would not reduce any silicon oxide present. The analysis of the positive and negative specimens

showed no difference; the always very small oxygen content could no exactly be determined. The presence of iron, the common impurity of Si diminished the thermoelectric force in both varieties, without affecting th sign. The density of the two varieties was the same, 2·33. The varieti might represent two modifications, as they also differ in rectifying powe [Abs. 71 (1917)]; but neither heating up to 1200°, nor rapid coolin changed the sign of the thermoelectric force. On the other hand, negativ Si turned positive when heated in a vacuum electric furnace. The autho conclude that it seems after all most likely that pure Si, free of oxygen, positive, and that it turns negative when oxidised. All impurities dimini the thermoelectric force. H.

1017. *Thermoelectric Effect in Carbon-Platinum Couples.* **M. La Ros** (N. Cimento, 12. pp. 284–301, Dec. 1916.)—Carbon behaves like a met (number of electrons not affected by temperature) rather than as a so-calle variable element, there being a neutral point; and the specific heat o electricity follows the law of proportionality to the absolute temperatur And there are no phenomena of hysteresis. The author's results differ co siderably from those of Buchanan, and from those of Dewar and Fleming but he considers he has detected and avoided pitfalls into which they hav fallen. The whole subject, he thinks, needs revision. A.

1018. *Influence of Temperature on Electro-capillary Phenomena.* **Décombe.** (Comptes Rendus, 164. pp. 808–811, May 21, 1917.)—Th author applies the second law of thermodynamics to electro-capillary phenc mena, making use of the experimental results obtained by Vining and b Gouy. A.

1019. *Alternating-current Bridge Method of comparing Inductances.* **Parnell.** (Phys. Soc., Proc. 29. pp. 259–268; Disc., 268, June, 1917.)— Describes a method of avoiding the double adjustment necessary in th Maxwell inductance bridge by the use of a current detector whose deflectio depends on the component of the current in quadrature with the e.m.f. applied to the bridge. The arrangement is shown in the Fig., and it i



demonstrated that if R, r, and s are all large compared with p, q, g, $P\omega$, an $Q\omega$, with R in circuit the balance depends chiefly on the inductances P and Q, and with K in circuit the balance depends chiefly on the resistances. The method is as follows: With R in circuit, s is adjusted for no deflection this gives an approximate balance for the inductances. Then with K in circuit, q is adjusted for no deflection; this gives an approximate balance for the resistances. The process is repeated, and after a few balances, value of s and q are obtained that give a balance with either R or K in circuit, in which case the bridge is completely balanced, and $P/Q = p/q = r/s$. The

first few balances need only be made roughly, and the whole process can be carried out very quickly; the author states that when the apparatus is adjusted an unknown inductance can be balanced against a standard to one part in a few thousand in a few minutes. As detector a sensitive moving-coil galvanometer in conjunction with a commutator, or, preferably, a Sumpner electro-dynamometer, may be employed. J. W. T. W.

1020. *Electric measuring Instruments with Parabolic Law of Deflection.* **J. K. A. W. Salomonson.** (K. Akad. Amsterdam, Proc. 19. 6. pp. 896–899, 1917. Electrician, 79. pp. 901–902, Sept. 7, 1917. Abstract.)—In current- or voltage-measuring instruments the deflection is either about proportional to the current strength, or it grows with the square of the current strength. In this way they constitute two different classes of instruments. The ordinary galvanometer with a moving coil or magnet belongs to the first group, the deflection in which obeys a linear law. The electro-dynamometer is a prototype of the second class, in which a quadratic law prevails. If the movable part of an instrument of the first group be mechanically coupled to the movable part of an instrument of the second type the rotating axes of the two instruments being made to coincide, and we send the same current through both instruments, taking care that the constituents of the movable part try to move it in an opposite direction, we have got a new instrument type showing a few peculiarities which are not to be found in either of the constituent parts. If I be the current strength, ϕ the deflection, a the constant of the galvanometric part, b the dynamometric constant, we know that $I = a\phi$ and $I = b\sqrt{(\phi)}$, from which it follows that for the two parts used together $\phi = I/a - I^2/b^2$. This is the equation for a parabola. Such an instrument then is said to have a parabolic law of deflection. The deflection is zero when $I = 0$ or when $I = b^2/a$. If we regard as positive the direction of the movement of the movable system when the dynamometric part has been short-circuited we find that a max. positive deflection occurs when $I = b^2/2a$, the deflection being $\phi = b^2/4a^2$. Any current between $I = 0$ and $I = b^2/a$ gives a positive deflection; currents larger than $I = b^2/a$ cause negative deflections. For very small currents we have a sensibility $= a$, which means that a current $I = a$ gives a deflection of one division of the scale. Near the second position of equilibrium a current increment of $-a$, or a current decrement of $+a$, augments a positive or decreases a negative deflection by one part of the scale. The absolute sensibility of the instrument is the same either in the first or in the second zero position. The relative sensibility, *i.e.* the ratio of the current increment causing an increase of one part of the scale into the current strength, approaches to 0 in the first zero position; in the second zero position it is $b^2/2a^2$, which will generally be a very large figure. Instead of proceeding in this way we preferably calculate the relative sensibility for the current causing the largest deflection at which the linear law still holds good. Expressed in this way the relative sensibility will generally be of the order of 200 to 500. But in the second zero position we can easily obtain a relative sensibility of 100,000 or more. Even with a moderate ratio between a and b^2 we obtain very high figures for the sensibility near the second zero position. We can only use very small parts of the parabola in most cases. In instruments of this kind the thing aimed at is a high relative sensibility near the second zero position; for example, take an instrument giving a full scale deflection at 10 milliamps., and which has its second zero position at say 1 amp.; in this case a change in the current strength of only 1 % would

cause the spot to leave the scale. The author has used the instrument to indicate the degree of constancy of a potentiometer current. We can easily give such an instrument any relative or absolute sensibility. With a shunt to the galvanometer part we diminish the relative sensibility; with a shunt to the dynamometer part we increase it. A shunt to the complete instrument increases the current strength for the second zero position. The author discusses the objection to using the instrument as a standard or normal instrument. He also shows how such an instrument can be used for detecting or even measuring small changes in the horizontal intensity of the earth's magnetic field. I. W.

1021. *Comparison of Different Types of Emanation-electroscopes.* **T. H. Leaming, H. Schlundt,** and **J. Underwood.** (Am. Electrochem. Soc. Trans. 30. pp. 365–378, 1916. Mech. Eng. 39. pp. 449–452, June 22, 1917.)—Electroscopes are generally standardised by introducing known quantities of emanation which may conveniently be obtained from weighed samples of pitchblende, or from suitable volumes of a standard radium solution. Since the emanation is distributed throughout the space of the ionisation chamber, some of the α-particles will not have their max. range in air, and consequently the ionisation current measured will not represent the max. ionisation which the radiations are capable of producing. It is therefore evident that the ionisation currents due to equal quantities of emanation in different types of ionisation chambers will have somewhat different values. Duane and Laborde [Abs. 926 (1910)] have deduced an empirical formula for the ionisation currents in ionisation chambers of different volume (v) and surface area (s), namely : $I=K(1-Cs/v)$, where K and C are constants. The numerical value of K depends on the quantity of emanation that is made the reference unit. The constant C is a fraction—the "reduction factor."

Three types of electroscopes, widely used for determining radium by the emanation method, were standardised with known quantities of emanation. The electrical constants of the instruments were determined and the dimensions of the ionisation chambers taken. From the combined data the authors have computed the ionisation current per curie of emanation at the time of max. activity. A. B. W.

1022. *Secondary Potential of an Induction Coil at "Make."* **E. T. Jones.** (Phil. Mag. 33. pp. 322–334, April, 1917.)—The chief interest attaching to a calculation of the potential at the secondary terminals of an induction coil at "make" lies in the means which the result may suggest for the reduction of this quantity. In several of the processes in which induction-coil discharges are used, and especially in X-ray work, it is desirable to suppress the "inverse current" at make; and even if one of the usual rectifying devices is employed for the purpose—most of these are said to be but imperfect rectifiers—it is still important to reduce as far as possible the max. potential to which the secondary terminals rise after contact is made at the interrupter. In considering the various methods by which the "make" potential may be reduced, the importance should be borne in mind of maintaining undiminished the potential at break. Assuming the secondary circuit to be open, the author deduces an expression for the "make" potential V_2 in terms of the various coefficients of the two circuits. If E is the battery e.m.f. in the primary, L_{21} the coefficient of induction of the primary coil on the secondary, L_{12} that of the secondary on the primary, and $\tan\theta=(k_1-\delta)/2\pi n$, then $V_2=(EL_{21}/L_1)\,[e^{-k_1 t}\cos(2\pi t-\theta)-e^{-\delta t}]$. The wave of potential in the secondary circuit at make thus consists of a

damped oscillation superposed upon an exponentially decaying part, the initial values of the two parts being $\pm EL_{21}/L_1$. The greatest numerical value of the above expression for V_2 occurs at a time t_1 somewhat less than $1/2n$, and will in all cases be less than $2EL_{21}/L_1$, the value of the maximum when k_1 and δ are zero. The expression $2EL_{21}/L_1$ may be regarded as giving the limiting value of the max. potential at make, to which the actual value would approximate if k_1 and δ were indefinitely reduced. In actual cases, however, k_1 and δ are probably never so small as to allow the above limit to be very clearly approached. V_2 is proportional to E, but it depends to a much smaller extent (only through k_1 and δ) on the resistance in the primary circuit. These results agree with experiment, *e.g.* a certain 18-in. coil, excited by a slow interrupter, gave at $E = 20$ volts, $R_1 = 10$ ohms, a "make" spark about 0·7 mm. long. With $E = 98$ volts and the same resistance in the primary the spark-length at make was 4·5 mm. These sparks represented potentials of about 3500 and 16,000 volts respectively. When the primary resistance was increased to 50 ohms the spark-length at make ($E = 98$ volts) only fell to 3·7 mm. Thus the potential at make increases rapidly with the battery e.m.f., but only varies slightly with the primary current. On the other hand, the p.d. at break depends greatly upon the primary current, being proportional to the value of this current at the moment of interruption. Consequently it is desirable to employ the smallest battery that is sufficient to produce the required potential at break. Frequently the conditions of supply do not permit of a variation in E. V_2 may also be reduced by diminishing L_{21}; this can be effected without causing any alteration in L_1 by withdrawing the primary and the core axially from their symmetrical position in the secondary. On one occasion, for example, the 18-in. coil with the primary in the position of max. mutual inductance gave a make-spark 4·4 mm. long [$E = 98$ volts, $R_1 = 12$ ohms]; when the primary was drawn out 30 cm. from this position the spark-length at make was only 1·5 mm. It might be thought that the displacement of the primary coil would, owing to the decrease of mutual inductance which it entails, cause a diminution of the secondary spark-length at *break*, but this is not necessarily the case. By drawing out the primary the system may be brought into one of the adjustments which are most favourable to the conversion of magnetic energy of the primary current into electrostatic energy in the secondary circuit. V_2 also varies inversely as L_1. Thus the addition of an air-core coil of 0·07 henry to the primary circuit of the 18-in. coil, the total resistance of the primary circuit [10 ohms] being kept constant, reduced the "make" spark from 4·5 mm. to 2·7 mm. The effect is even more marked when the four layers of the primary coil are connected in parallel, L_1 being now much smaller to begin with. The insertion of the air-core coil now reduces the spark-length at make from 13·1 to 1·0 mm. The series inductance also increases the secondary potential at the *interruption* of a given primary current, and increases the spark-length of the coil for a given mean primary current. The author also discusses in detail another way in which the primary self-inductance can be changed, namely by connecting the layers of the primary coil in series or in parallel or in other ways. The nature, and to some extent the magnitude, of the effects produced in the different cases are illustrated by the data given in the paper. The values used are typical of a fairly large [18- or 20-in.] coil. I. W.

1023. *Rectifier with Soldered Contact.* **C. Bergholm.** (Ann. d. Physik, 52. 1. pp. 101–104, Feb. 15, 1917.)—Describes a special form of construction

in which a piece of molybdenite, held in the usual way in fusible alloy, is used in conjunction with a Pt-wire in such a manner that the Pt point is located, by search, just over a sensitive spot and is there soldered (with the aid of kathode-sputtered gold if necessary). As a detector of weak alternating currents of low frequency such a "couple" will respond to the current given out by a telephone receiver (150 ohms resistance) held at 1 metre distance from a tuning-fork. With a galvanometer of sensibility $6{\cdot}7 \times 10^{-9}$ amp. (60 ohms resistance) the deflection was 9 mm. L. H. W.

1024. *Apparatus for Measurement of Electric Resistance at High Temperatures and its Application to Determination of Critical Points of Iron and Steel.* **P. Saldau.** (Iron and Steel Inst., Carnegie Schol. Mem. 7. pp. 195–231, 1916.)—In the special apparatus designed by the author, measurements were made on Kahlbaum pure iron, electrolytic iron, and a series of pure steels containing 0·11 to 1·54 % carbon, in an atmosphere of coal gas. Temperature-conductivity graphs show that the variation in resistance follows a parabolic curve up to 700° C. and that at any particular temperature the resistance is always greater on heating than on cooling, but as the ordinary temperature is approached the differences diminish in magnitude. There are sharply defined discontinuities in the curves at the critical points and the G O S E line of the iron-carbon equilibrium diagram has been re-determined by this method. There are indications that the point A*r*3 in pure iron is higher than 910° C., the temperature which is now generally adopted for A*r*3. A slight discontinuity in the curve also occurs at 930° C.; this is, however, not regarded as a transformation, but rather as the limit at which the growth of the crystallites of the solid solution increases more rapidly than the temperature. It is highly probable that the change is unaccompanied by any thermal effect. Benedicks' formula $\rho = 7{\cdot}6 + 26{\cdot}82\,\Sigma\,C$ is shown to be not strictly correct. Eutectoid steel has a considerably higher resistance than its neighbours at all temperatures up to 760° C. F. C. A. H. L.

ALTERNATING CURRENTS AND MAGNETISM.

1025. *Initial Magnetisation as a Function of Temperature.* **P. Weiss** and **J. de Freudenreich.** (Archives des Sciences, 42. pp. 5–13, July, and pp. 449–470, Dec., 1916.)—In continuation of previous work [see Abs. 1766 (1915)], a ring of Fe_2Co was prepared from pure constituents and examined in a constant field with varying temperature. The temperature-magnetisation curve exhibits several maxima between 445° and 1025° C.; at the latter temperature the magnetisation disappears. Observations were also taken of the magnetisation in increasing fields at constant temperature. Taking the relation between susceptibility and field as $K = a + bH$, the coefficients a and b had been found by Radanovic and Renger to be functions of the temperature. Also an equation connecting a and b had been stated. In the case of ferro-cobalt, whose properties differ totally from those of the other substances examined, there is no definite relation between the coefficients a and b; in general, both a and b increase with temperature. The substance nickel was re-examined, and the previous results in great measure confirmed. Finally, an attempt is made to explain the irreversible portion of the initial magnetisation by assuming that in a body of confused crystalline structure the elementary crystals have properties similar to those of the crystal of pyrrhotine.

G. E. A.

1026. *Thermomagnetic Properties of the Carbides found in Steels.* **K. Honda** and **T. Murakami.** (Tôhoku Univ., Sci. Reports, 6. pp. 23–29, June, 1917.)—Previous results of magnetic analysis have led the authors to conclude that the critical temperature of iron cementite is 210° C., and that of the double carbide of iron and tungsten 400° C. In the present paper the authors have determined these critical temperatures directly, using carbides separated electrolytically from carbon and tungsten steels as described by Arnold and Read [Abs. 604 (1915)]. The iron cementite obtained was a grey powder, and had the composition C, 6·08 % ; Fe, 93·5 %. The double carbide was a black powder containing C, 8·10 % ; Fe, 31·71 % ; W, 53·70 %. To investigate the magnetic properties, the powders were compressed in cylindrical tubes, and the specific magnetisation referred to unit mass was taken as the characteristic property of the substance. The curves given in the paper show that the specific magnetisation of iron cementite increases nearly proportional to the magnetising field up to 500 gauss, and the value in this field is 19·7, or about 1/10th of that of pure iron. The curve of magnetisation for the double carbide bends slightly down as the field increases, and attains a value 15·5 in a field of 500 gauss. The linear relation is not a characteristic of cementite, reduced iron and cobalt, when examined in the form of compressed powder showing a similar relation.

Magnetisation-temperature curves are also given in the paper. The critical temperature of cementite is 215° C., and of the double carbide 400° C. The effect of heat on the decomposition of the carbides is also studied. The material was heated *in vacuo* to various high temperatures, 400°, 500°, 600°, etc., and the magnetisation-temperature curves taken during heating and cooling. If decomposition takes place at high temperatures an abrupt change of magnetisation will be observed. It appears that cementite, in its free state, is almost wholly decomposed into its components by prolonged heating at 900° C., and the double carbide at 850° C. L. L.

1027. *Changes in Young's Modulus of Nickel with Magnetic Fields.* **W. Brown.** (Roy. Dublin Soc., Proc. 15. pp. 185–192, April, 1917.)—Measurements of the modulus of nickel wires have been made with longitudinal and transverse magnetic fields, both direct and alternating. It was found that 80 c.g.s. units was the highest field that could be safely applied without special cooling arrangements, and accordingly this was the max. field value used. In longitudinal fields the modulus at first decreases with increasing strength of field, passing through a minimum at about 23 c.g.s. units. The changes are smaller in alternating than in direct fields. In transverse fields the modulus at first increases with increasing strength of field, and passes through a maximum at about 40 c.g.s. units in both direct and alternating fields. The changes are greater in direct than in alternating fields. Honda and Terada have previously shown [Abs. 477 (1907)] with longitudinal magnetic fields that when the constant load is increased the field in which the minimum value of the modulus occurs is increased, but the actual value of the modulus is diminished. The author's results show that with transverse fields the reverse is the case ; *i.e.* when the constant load is increased the field in which the max. value of the modulus occurs is decreased, and the actual value of the modulus in that field is increased. Further experiments show that when the frequency of the alternating field is increased the variations in the modulus are decreased. F. C. A. H. L.

1028. *Magnetic Properties of Manganese-Antimony Alloys.* **K. Honda** and **T. Ishiwara.** (Tôhoku Univ., Sci. Reports, 6. pp. 9–21, June, 1917.)—The

alloys Mn-Sb have been studied by R. S. Williams [Abs. 1712 (1907)], and their magnetic properties have been previously investigated by K. Honda [Abs. 1335 (1910)]. In the research cited Honda employed small specimens and only weak magnetising fields. In the present paper larger specimens have been subjected to magnetising fields up to 500 gauss. In addition, the intensity of magnetisation has been measured in a field of about 5000 gauss to obtain the saturation value. The alloys investigated contained 2, 5, 10, 20, 28, 31·4, 40·7 47·8, 55, 60, and 70 % of Mn respectively, and the results obtained are represented in a series of I-H and I-temperature curves.

According to Williams the structure of these alloys is—

0–31·4 % Mn	Sb + saturated solid solution with 31·4 % Mn.
31·4–40·7 % Mn	Unsaturated solid solution of Mn_3Sb_2 + Sb.
40·7–47·8 % Mn	Mn_3Sb_2 + Mn_2Sb.
47·8–50·5 % Mn	Unsaturated solid solution of Mn_2Sb + Mn.
50·5–100 % Mn	Saturated solid solution of 50·5 % Mn + Mn.

The intensity of magnetisation at first increases rapidly with the percentage of Mn, a maximum being reached at 31·4 %. It then decreases through the alloy corresponding to the composition Mn_3Sb_2 to the alloy Mn_2Sb, where the magnetisation reaches a minimum. It then begins to increase, and reaches a maximum at about 50 % of Mn ; from this point the magnetisation gradually decreases to zero as the content of Mn increases. These results agree with those of the former investigation. Saturation is apparently not attained in a field of 5000 gauss in the case of the 2, 5, 40·7, 47·8, and 60 % alloys. The magnetisation-temperature curves show that the critical temperature for alloys with a content less than 40·7 % Mn is 315° C., and for the remaining alloys 275° C. The critical temperature of Mn_3Sb_2 is 315° C. and of Mn_2Sb is 275° C. When the Mn content is 40·7 % or greater, the magnetisation temperature curve descends slowly at first and then rapidly as the critical temperature is approached. If the content is 31·4 % Mn or less the curve rises at first to a maximum and then descends to the critical temperature. The authors account for this from the point of view of the constitution of the alloy and the known behaviour of a ferromagnetic substance under a strong field as the temperature increases. For all alloys the effect of temperature on magnetisation is almost reversible for heating and cooling.

The susceptibility of the alloys above the critical temperature was also measured, and the results are represented graphically. Changes in structure are indicated by abrupt variations in the susceptibility, and the results are such as to be expected from Williams' equilibrium diagram for these alloys.

The magnetic observation at high temperatures may serve for detecting the condition of equilibrium of a system of alloys, just as the cooling curve does. The magnetic method is not so simple as the thermal one, but it locates exactly a transformation and its progress, whereas the thermal method is complicated by time-lag. L. L.

1029. *Aeroplane Compasses.* **S. G. Starling.** (Engineering, 104. pp. 69–70, July 20, 1917. Abstract of paper read before the Optical Soc.)—Discusses the errors to which an aeroplane compass is liable, the most troublesome being that due to "banking" when the aeroplane is turning. If no side-slip occurs the resultant of the gravity force mg and of the centrifugal force mv^2/r^2 (v being the velocity and r the radius of the turn) is at right angles to the aeroplane base, and the card keeps the position with respect to the bowl which it had before the turn. The tilt of the card is thus the same

as that of the machine, and the card equilibrium is no longer in the N.–S. direction of the magnetic meridian. When the equilibrium positions for a complete turn through 360° are calculated from the vertical and horizontal components V and H of the terrestrial magnetic field very peculiar results are obtained. For a tilt of 23° (the complement of the magnetic dip at London) the card is in a neutral position when the course is magnetic E., because then the card is at right angles to the resultant magnetic field. At tilts greater than 23° the error may reach 180°, *i.e.* the card may point S. instead of N. on an easterly course ; and the deviations for easterly and westerly courses are not symmetrical.

To correct for tilting the author uses two bar magnets, so fixed symmetrically to the compass with their N. pointing downwards to a tilting lever that the magnets remain vertical to the cards when the aeroplane tilts, and that their S.–N. field is equal and opposite to the V force. He further attaches soft-iron correctors to a "tilt-measurer." The effective weight of a body A of mass m on an aeroplane is itself affected by centrifugal force when the aeroplane is at a tilt ϕ and is equal to $mg/\cos\phi$. If A be attached to the centre of a spiral flat spring and provided with a pointer, the deflection of the pointer will measure the tilt ; with the aid of this spring the correcting masses of soft iron can be approached to the compass as the tilt increases. In this way the error due to banking can be reduced to a great extent, and the magnets will resume their horizontal position on the completion of the turn. J. W. T. W.

1030. *Variation of Electrical Resistance due to a Magnetic Field.* **E. Freda.** (N. Cimento, 12. pp. 177–193, Oct., 1916.)—The author gives a *résumé* of the theories proposed to explain the apparent change of resistance in conductors placed in a magnetic field. This is followed by a mathematical investigation carried out to see whether Drude's electronic theory accounts for the experimental results, or if it is necessary to introduce the hypothesis that an alteration occurs in the specific properties of the conductor under the action of the field.

Neither the theory nor the suggested hypothesis gives a complete explanation of the phenomenon. V. C.

1031. *Paramagnetism and Chemical Dissymmetry.* **A. Quartaroli.** (Soc. Chim. Ital., Gazzetta, 46. i. pp. 225–230, 1916.)—Observations on the compounds of the magnetic elements show that the paramagnetism is greatest for those salts which have the lowest values for the ratio between the saturated valencies and the saturable valencies calculated according to the limiting types of the groups to which the metals belong. This relation becomes still more exact when account is taken of the greater or less facility with which the limited valencies are reached. A number of data are quoted in support of this conclusion. T. H. P.

1032. *Ferrous Iron Content and Magnetic Susceptibility of Some Artificial and Natural Oxides of Iron.* **R. B. Sosman** and **J. C. Hostetter.** (Am. Inst. Mining Eng., Bull. No. 126. pp. 907–931, June, 1917.)—A description of experiments made on a large number of specimens to find the relation between the ferrous iron percentage of an iron oxide and its magnetic properties, the oxide being in the form of a powder. The measurements were made by weighing the force exerted on a known weight of the substance by a non-uniform magnetic field. The ferrous iron in the sample was deter-

mined by a titration method, except when the content was of the order of 0·1 %, when an electrical method was employed. The effect of the shape of the particles on the magnetic results was neutralised as far as possible by powdering the samples to the same degree of fineness, and samples of magnetite and magnetite-quartz mixtures were employed as magnetic standards. The observations on the latter bodies show that dilution of the magnetite diminishes the induction by an amount which is greater, the greater the dilution. An effect which had to be guarded against was the oxidation of the magnetite as a result of prolonged powdering in the mortar.

In general, in artificial oxides, the magnetic susceptibility is proportional to the ferrous iron content; the so-called magnetic ferric oxide is, however, a striking exception to this rule. Further, when the percentage of FeO is below about 0·2 %, the results become irregular. The colours of the powdered oxides are stated in terms of Ridgeway's standards. The natural iron-oxide minerals are similar to the artificial in being, in many cases, solid solutions of Fe_3O_4 in Fe_2O_3; others are mixtures of Fe_3O_4 and Fe_2O_3. When the ferrous iron is not in solid solution or in magnetite admixture, the magnetic susceptibility falls below the normal. G. E. A.

1033. *Magnetic "Activity" and Hourly Ranges.* **C. Chree.** (Terrest. Magn. 22. pp. 57–83, June, 1917.)—A rough measure of the magnetic activity of any day is at present obtained by taking the mean of the "character" figures (0, 1 or 2) assigned to that day at stations scattered over the globe. While the figure thus arrived at gives a good indication as to whether a day was quiet or much disturbed, it cannot be regarded as being a satisfactory quantitative measure. Bidlingmaier has suggested a method of distinguishing between days by securing an estimate of the energy which goes to produce all the magnetic changes of the day, regular and irregular. To make an accurate determination of this energy requires measurements of the magnetic curves at short intervals of time; 6-minute intervals proved almost too long, and the work involved in carrying out such a scheme regularly thus becomes prohibitive. To overcome this drawback Bidlingmaier suggested certain empirical rules by means of which the energy would be determined from hourly readings of the magnetic elements, together with the range of movement in each hour. A large part of the present paper is devoted to testing the validity of these rules, making use of quick-run data from observatories in different parts of the world. The conclusion reached is not very favourable to Bidlingmaier's method. It is suggested that the deduction of the daily activity at one step by assuming it proportional to the square of the absolute daily range, is an alternative worth considering. The results for individual days at individual stations might not be of great accuracy, but a determination of world activity from the mean of 30 or 40 stations, would probably be quite satisfactory. The labour involved would be of the nature of 1/50th of that involved in Bidlingmaier's method, and would be well within the capacity of the great majority of observatories. J. S. Di.

1034. *Activity of the Earth's Magnetism.* **D. L. Hazard.** (Terrest. Magn. 22. pp. 84–86, June, 1917.)—An inquiry into the accuracy of Bidlingmaier's empirical rules [see preceding Abs.] as applied to the records of the Cheltenham Magnetic Observatory during 1915. It is found that satisfactory results can be obtained by the use of a formula of the same type as Bidlingmaier's though differing in detail. J. S. Di.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

1035. *The Characteristic Curve of X-ray Tubes.* **N[ella] Mortara.** (N. Cimento, 12. pp. 133–143, Sept., 1916.)—The V,*i* curve for various p.d.'s and strengths of current, both for direct and alternating currents, is a straight line of the type $V = a + bi$. With a given hardness a and b remain constant: with increase of hardness a has a higher value. On varying the hardness in one and the same tube, a varies but b does not. In different tubes, the value of b differs slightly. There is nothing of the nature of hysteresis, at any rate up to 10 milliamps. A. D.

1036. *Determination of the Practical Constants of the Coolidge Tube.* **M. Boll** and **L. Mallet.** (Comptes Rendus, 163. pp. 302–305, Sept. 25, 1916.)—The authors have experimented with the Coolidge tube with a view to clearing up some erroneous ideas which have cropped up as to its working. Their results show that it is erroneous to assume (*a*) that the intensity of the radiation emitted always increases with the current which passes through the tube; (*b*) that, with a constant potential on the tube, the degree of penetration of the rays is independent of the current through the tube; (*c*) that, with a constant current flowing through the incandescent filament, the intensity of the radiation emitted is sensibly independent of the voltage on the tube, and (*d*) that, with constant potential on the tube, the output of the tube passes through a maximum as the current through the tube increases. The final conclusions arrived at are the following:—(1) The Coolidge tube is very stable. For a given voltage and milliampereage, the X-radiation maintains its original characteristics as to total emission and degree of penetration for a very long time. (2) The tube is very "supple." It may be changed from "hard" to "soft," or *vice versa* without any trouble. (3) The output of the tube is similar to that of other focus tubes for soft rays, but it becomes superior to them when the applied voltage is high. (4) The radiation emitted by a Coolidge tube can be about 20 times as intense as that from an ordinary tube, and rays of a penetration of 10° Benoist can be produced of the same intensity as rays of a penetration 7° Benoist from an ordinary tube. E. A. O.

1037. *Stereo-radioscopy.* **Lièvre.** (Comptes Rendus, 164. pp. 833–834, May 21, 1917.)—The apparatus described enables a direct stereoscopic view of images projected upon the screen to be obtained. The surgeon sees the projectiles in their real plane, knows the relationship between them and the bones, and appreciates the distance which separates the instruments from the foreign body. Either two ordinary tubes or a single one with double antikathode may be employed. The two antikathodes functioning alternately by means of a rotating commutator in the secondary circuit, project a double image on the screen. This double image is impressed upon the eyes by allowing it to pass a shutter formed of two discs rotating in the inverse direction, the spaces and solid parts of which correspond to the periods of opening and closing of the current upon the corresponding antikathode.

The apparatus is light, takes up little space, can be adapted to almost any continuous- or alternating-current installation, and allows the examination to be made in either a horizontal or vertical position. A. E. G.

1038. *Radiological Dosimetry.* **R. Ledoux-Lebard** and **A. Dauvillier.** (Comptes Rendus, 163. pp. 667–669, Nov. 27, 1916.)—Additional to Abstracts Nos. 726 and 1294 (1916) in regard to an arrangement for producing X-rays of high frequency and of sufficient intensity from heavy metals for use in radio-therapy. E. A. O.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1039. *The Conception of the Element and the Atom in Chemistry and Radiology.* **F. Paneth.** (Zeits. Phys. Chem. 91. 2. pp. 171–198, Feb. 29, 1916.)—Modern theoretical chemistry rests upon Boyle's definition of an element as a substance which cannot further be decomposed, and on Dalton's rule that all the atoms of an element have equal weight, and that there are as many kinds of atoms as elements. The discovery of radio-active disintegration, of isotopy and of the linear system of Moseley—as distinct from the periodic system—call for a revision of these definitions. Radiologists speak of isotopes as different elements, the number of which would be very large ; isotopes should be regarded as varieties of one and the same element. An element should be defined as a substance which cannot be simplified by chemical means ; and two substances, which satisfy this condition and which cannot be separated again after being mixed, should be regarded as one and the same element. Atoms are the bricks of matter which chemical separation can furnish, and which themselves remain intact in all chemical reactions. On these views the following statements are made in the summary :—The number of chemical elements is 92, 5 of which have not yet been discovered. The chemical and electrochemical properties, the light and the Röntgen-ray spectrum, and the number of nuclear charges characterise each element. Atomic weight and radio-active properties are not constants of the element. There are more kinds of atoms than elements—120 varieties of atoms are known, the number of undiscovered atoms is unknown. An element may consist wholly of atoms of the same kind (pure element), or it may consist of atoms differing as to weight or radio-activity or both these properties (mixed element) ; in chemical mass-action isotopic atoms can completely replace one another, so that in the formulæ of chemistry and electrochemistry the sum of the atoms of different varieties of that element is to be entered as concentration of a mixed element. The radio-active disintegration of an atom leads immediately to the production of an atom of another element, but further disintegration may again result in an atom of the original element. H. B.

1040. *Electron Theory and Chemical Action.* **W. A. Noyes.** (Am. Chem. Soc., J. 39. pp. 879–882, May, 1917. Nat. Acad. Sci., Proc. 3. pp. 356–360, May, 1917. Chem. News, 115. pp. 43–44, July 27, 1917.)—The author suggests that the apparent localisation of the affinities in particular parts of atoms which seems to be indicated by many properties of organic compounds might possibly be accounted for by a valency atom revolving about the positive nucleus of one atom including in its orbit the nucleus of a closely contiguous atom. For during that portion of the orbit within the second atom the latter would, as a whole, be negative, while the first atom remained positive. During the remainder of the orbit both atoms would be electrically neutral, and might then tend to separate. But the mobility of an atom is so small compared to that of an electron, that the effect of such an orbit might well be to hold the atoms together. G. W. DE T.

1041. *Hydrogen-Helium Atomic Evolution Hypothesis.* **W. D. Harkins.** (Am. Chem. Soc., J. 39. pp. 856–879, May, 1917.)—The author has in previous papers [see Abs. 127, 128, 381 (1916)] argued that the elements may probably

be intra-atomic hydrogen compounds, and that an early step in the formation of a complex atom is the change of H into He. He here shows that, on his hypothesis, the elements fall into two distinct series, one of even atomic number, represented by the general formula nHe ; and one of odd atomic number, represented by $n\text{He} + H_3$. If this be so, it is to be expected that the two series should exhibit some marked difference. A large amount of evidence is adduced in support of the author's contention that such a distinction is found in the greater abundance in which the atoms of the even series are found in nature, as compared with atoms in the odd series nearly adjacent to them in a series arranged in ascending order of atomic number. He claims that this should be regarded as a *New Periodic Series* fundamentally related to the atomic structure, and apparently considers the Mendeléeff Series as being related mainly to the group of free electrons associated with the atom. G. W. DE T.

1042. *New Element.* **W. Bramley.** (Chem. News, 115. p. 47, July 27, 1917.)—Analytical results are given which do not agree with the supposed "new element" [see Abs. 820 (1917)] being identical with europium. The atomic weight is probably less than half that of europium. T. S. P.

1043. *Development of Glass Furnaces on the Continent.* **T. Teisen.** (Chem. News, 115. p. 154, March 30, 1917. Paper read before the Soc. of Glass Technology, March, 1917.)—For heating furnaces wood and even peat are used in Scandinavia in some works, whilst natural gas is used in the United States to some extent. The chief fuel in use, however, is coal, either burned direct or converted into gas. When coal is burned direct a large excess of heat is necessary to complete the combustion, and if this excess be cut down the waste gases contain a large proportion of carbon monoxide, entailing considerable loss of heat. In the complete combustion of 1 kg. of coal to CO_2 8000 kg. cals. are set free ; but if the coal is only burned to CO only 2500 kg. cals. are set free. The use of producer gas allows much better combustion to be obtained, so that large excess of air is unnecessary. Higher temperature results, especially if the air and incoming gas are delivered hot to the combustion chamber. This preheating of air and gas can be done in two ways—(1) by regeneration, (2) by recuperation. In the latest pattern of Siemens regenerative furnace there are four fire-brick chambers, one pair being heated by the waste gases, whilst the other pair is warming the incoming air and gas. By reversing the direction of flow, the functions of the two pairs of chambers are exchanged. This regeneration method is very useful for large furnaces, but is expensive, and takes up much floor space. In the Hermanssen system of recuperation the air and gas always pass in the same direction, and are heated by passing through flues surrounded by the hot waste gases. The combustion is so perfect that at the Costa works crystal glass is made in open pots. Furnaces of this type will melt glass during the night for next day, so that the capacity of the furnace should not be judged by the number of pots, but by the amount of glass it will melt. From this standpoint the continuous recuperative furnace is more efficient than the regenerative. A. E.

1044. *Polymorphic Transformations of Solids under Pressure.* **P. W. Bridgman.** (Am. Acad., Proc. 51. pp. 55–124, Sept., 1915.)—In this paper data are given sufficient for a thermodynamic specification of a number of polymorphic transitions between solids. Besides the transition quantities themselves (change of volume, latent heat, slope of the transition line) it has

been possible in a good many cases to give at least a rough approximation t the difference of compressibility, thermal expansion, and specific heat of th reacting phases. The experimental procedure is described in detail and i followed by a theoretical discussion of the effect of impurities on the transi tion lines and on the equation of the transition lines. Then data are give of the following substances :—Potassium sulphocyanide, ammonium sulpho cyanide, potassium sulphide, potassium chlorate, potassium nitrate, carbo trichloride, carbon tetrabromide, silver iodide, mercuric iodide, phenol, an urethane. The paper is the first of several which are to deal with soli transitions under pressure, and contains the preliminary thermodynami discussion which will be necessary to all the work on solid transition [Some of the succeeding papers of this series have already been dealt with see Abs. 343, 344, 345 (1917).] H. H. Ho

1045. *Solubility of Hydrogen in Solid Alloys of Palladium with Gold, Silver Platinum.* **A. Sieverts, E. Jurisch,** and **A. Metz.** (Zeits. Anorg. Chem 92. 4. pp. 329–362, July 15, 1915.)—The absorption of hydrogen by Au-Pd had been studied by Jurisch, 1912, alloys of Pd-Ag and Pd-Pt later by Metz It had long been known that Pd did not absorb hydrogen under certain conditions, possibly connected with the purity of the hydrogen ; the author's hydrogen was re-liberated from Pd by heating. The experiments were made at pressures of 6, 187, 200, 323, 760 mm. and temperatures up to 822°. The ternary H-alloys seem to be real solid solutions; when Pd is regarded as solvent for H, the other metals influence the solubility after the manner of liquid solutions. Pure Ag, and probably also Au, does not appear to dissolve H, Pt dissolves little H. In all the three series of alloys the H solubility is approximately proportional (at a given temperature) to the square root of the gas pressure ; at constant pressure (especially at 1 atmo.) the solubility decreases as the temperature rises, whilst the solubility of H in Pt and in alloys with 50 % Pt increases with rising temperature. The curves of the Au and Ag alloys differ strongly from those of the Pt alloys. In Pt-Pd an increasing amount of Pt diminishes the absorption of H at all temperatures ; the less, the higher the temperature. In Ag-Pd the addition of Ag increases the H absorption up to 40 % Ag, then diminishes it ; the temperature influence on this increased solubility is peculiar for the range 40 to 50 % Ag ; it favours the increase from 800° down to 270°, then diminishes it. In Au-Pd alloys the Au influence is similar, but less marked, and the temperature peculiarities are not the same. The physical properties in general suggest that Pt does not belong to the groups Ag and Au. The percentage (both atomic and by weight) of 40 Ag has a special significance for Pd. Thermoelectrically Pd alloys with up to 80 % Au, and 70 % Ag are negative to Pd ; the addition of Ag to alloys lowers the temperature coefficient of resistance strongly. H. B.

1046. *Solidification of Silver-Arsenic Alloys.* **W. Heike** and **A. Leroux.** (Zeits. Anorg. Chem. 92. 3. pp. 119–126, 1915.)—In previous work Friedrich and Leroux (1906) had only experimented over a limited range at atmospheric pressure. The very pure As and Ag are fused in sealed tubes of porcelain or siloxide which are enclosed in an outer tube, the intermediate space being packed with sand when the vapour pressure is high ; 16 alloys are mentioned. The freezing-point curve shows only one eutectic point, at 540° and 25 atomic % of As (18·9 % weight) ; this alloy alone can be under-cooled. There are no compounds, although Ag_3As is often said to exist. On the top

of an alloy containing 13·8 atom. % of As hairy crystals of silver, 1 mm. long, were noticed. The formerly-found melting-point of arsenic was 830°; solidification is now observed at 814·5°; Goubau [Abs. 896 (1914)] found 817°. H. B.

1047. *Equilibrium Diagram of Mercury-Thallium Alloys.* **G. D. Roos.** (Zeits. Anorg. Chem. 94. 4. pp. 358–370, March 21, 1916.)—The only previous work of N. S. Kurnakow (1902) indicated a compound Hg_2Tl. As it is very difficult to avoid oxidation of the Tl, the author experimented in a CO_2 atmosphere, then under petroleum, and finally again in CO_2 carefully freed from oxygen; temperatures were measured by Pt and Pt-Rh couples and (down to — 60°) by copper-constantan couples. The correct formula for the compound is Hg_5Tl_2, corresponding to 28·57 % of Tl (all atomic percentages); different methods indicate a compound of from 28·5 to 28·7 % Tl. There is a molecular transformation, accompanied by evolution of heat and discontinuity in the expansion, at 11·8° C. The melting curves of the alloys ranging from 26 to 31 % Tl all have a maximum between 14·2° and 14·5°. In alloys containing 33 % Tl crystallisation begins at 11·8°. Crystallised thallium dissolves mercury, but crystallised mercury does not dissolve Tl; this is in accordance with Tammann's rule that the metal with higher melting-point forms solid solutions with that of lower melting-point, but not *vice versa*. Kurnakow's alloys were probably not free from oxide. The author's thallium is electrolytic; it melted at 301·5°, Kahlbaum's at 300·5°; Thöl had found 303°. H. B.

1048. *Gases Occluded in Alloy Steels.* **J. W. Donaldson.** (Iron and Steel Inst., Carnegie Schol. Mem. 7. pp. 41–54, 1916.)—A summary of the earlier work carried out on ordinary carbon steels indicates that the principal dissolved gases are CO and hydrogen which are evolved in largest quantities at the critical points. Four steels containing 3 to 3·5 % Ni, Si, Cr, and Mn respectively were investigated. The largest amount of gas was obtained from the Ni steel (2·46 cm.³ per. gm.), the volumes from the Si, Cr, and Mn steels diminishing in the order given. Practically no gas was evolved below 500° C.; as the temperature rose the volume of gas evolved increased to a maximum during the critical range and then decreased. It was found that CO and hydrogen predominated in the evolved gases: hydrogen at low temperatures and CO at high temperatures. The sum of the CO_2, CH_4, and N was in all cases less than 2·5 % of the total. Si and Mn decreased the amount of CO_2 present, and increased the amount of hydrogen. Cr tends to increase slightly the quantity of nitrogen present. F. C. A. H. L.

1049. *Hardness of Metallic Alloys.* **P. Ludwik.** (Zeits. Anorg. Chem. 94. 2. pp. 161–192, Feb. 29, 1916.)—As with metals [see Abs. 845 (1917)] the experiments were made by the cone-penetration method, the values being plotted against the "efficacy," defined from dilute solutions of equal concentration (by weight) as proportional to the number of atoms of the one constituent (or compound formed) in unit volume of the other, the solvent. The alloys were prepared in electric furnaces (Heraeus, or Hanemann, kryptol) at temperatures up to 2500° and quenched. The metals Al, Sb, Pb, Cu, Mg, Zn, Sn were alloyed with one another and sometimes also with Co, Ni, Mn, Bi, Cd, Ag; a few ternary alloys, Al-Cu-Ag and Al-Zn-Sn, were also tested. Some alloys changed in the course of four months, Al-Cu becoming harder by 10 %, and alloys of Zn with Cd, Al, Mg, and also with Al and Sn becoming softer by up to 25 %. The solutions were mostly dilute, of a few

per cent., from 0·5 up to 10 %. The hardness generally increased as the efficacy increased, and the hardening effect would thus primarily appear to depend upon the number of atoms of added metal. But there is no rule, and other factors enter. The addition of Bi and Sn to other metals gave too soft alloys, provided chemical compounds were not formed ; Mg made Bi and Al also too soft, whilst some Mg-Zn alloys were of unexpectedly high hardness. H. B.

1050. *Liquid Contraction in Cast Iron.* **G. Hailstone.** (Iron and Steel Inst., Carnegie School Mem. 7. pp. 55–67, 1916.)—Previously the author has shown that liquid contraction is accompanied by a decrease in density and that a max. solid contraction accompanies max. liquid contraction. A number of K bars of cast iron containing 3·25 to 3·31 % C, 1·9 % Si, 0092 to 0·114 % S, 1·41 to 1·48 % P, and 0·27 % Mn were cast at temperatures varying from 1428° to 1264° C. and submitted to various chemical, physical, and mechanical tests. As the casting temperature decreased, the density and tensile strength decreased rapidly. The content of graphitic carbon increased, and the combined carbon decreased, as the casting temperature was lowered. Under the microscope it was found that the size of the graphite increased and that of the MnS areas decreased, as the casting temperature fell. No relationship was found to exist between the Shore hardness number and the casting temperature, but the diam. of the indentation increased with decrease of density. Microscopic examination after suitable etching indicated that the bar cast at a high temperature contained the phosphide eutectic in the form of a network, while in the bar cast at the lowest temperature the phosphide was uniformly distributed, thus confirming the author's earlier conclusions (with F. J. Cook) that strength in cast iron is intimately bound up with the distribution of the phosphide eutectic. F. C. A. H. L.

1051. *Estimation of Carbon in Steels by Micrographic Methods.* **A. Portevin.** (Rev. de Mét. 13. pp. 426–428, Nov.–Dec., 1916.)—The use of the microscope in the estimation of carbon in steel is often attended by error owing to the following causes: (1) irregularity in the distribution of the carbon, (2) mode of relative distribution of the ferrite and pearlite, especially when the general structure is the banded structure typical of rolled products, (3) fineness of grain, (4) state of the pearlite, *i.e.* extent to which it is sorbitic, and (5) content of elements other than carbon, particularly Mn and Cr. The influence of C and Cr is to make the apparent carbon-content higher than the real content. F. C. A. H. L.

1052. *Oxygen Content of Iron and Steel and its Effect on their Properties.* **J. A. Pickard.** (Iron and Steel Inst., Carnegie Schol. Mem. 7. pp. 68–82, 1916.)—Determinations have been made of the oxygen contents of Bessemer steel, open-hearth steel, crucible steel, wrought iron, American ingot iron, and cast iron. More oxygen exists in wrought iron than in steel and a greater percentage exists in basic steel than in acid steel. No definite relationship exists between the oxygen content and that of other impurities, but it seems possible that the oxygen content would be a trustworthy criterion of the standard of works' practice. Small amounts of oxygen were found to occur even in white cast iron, but it is impossible to state in what form. From the study of ingot iron, it appears that the solubility of ferrous oxide in liquid iron is 0·405 %. Examination of samples of steel which had failed in practice showed that the existence of more than 0·01 % oxygen tends to produce unreliability under shock. F. C. A. H. L.

1053. *Heat Treatment of Large Forgings.* **W. Beardmore.** (Inst. Mech. Eng., J. 4. pp. 215–224; Disc., 236–302, March, 1917. Engineering, 103. pp. 270–271; Disc., 262–265, March 23, 1917.)—In order to obtain the necessary mechanical tests with forgings, it is not only needful to have suitable material, but the physical condition of the steel must be such that brittleness and the chance of sudden failure should be reduced to a minimum. This means that the steel must possess the smallest grain size; the slowness with which heavy masses of steel cool down results in large crystal grains at the centre of the mass, and to avoid this recourse has to be made to oil-quenching to hasten the cooling down, while a subsequent reheating is generally necessary to remove the hardness introduced by this quenching.

The effect of oil-quenching carbon steels diminishes, the farther one goes from the outside surface, and with very large forgings a limit may be reached at which the quenching effect at the centre is insufficient to confer any benefit on the material. The effect of work is very important, and there is an intimate relation between the grain condition of a forging and the amount of work which has been put on it during forging. For the best results the ratio of the cross-section of the ingot to the largest cross-section of the forging should have a minimum value which should not be less than three.

For high-tensile material, that is, material over 40 tons strength, where the factor of safety is limited owing to the special conditions under which the material has to be employed, it will generally be safer to use an alloy steel, since for the same tonnage a very much tougher material may be developed. The subject is dealt with from a practical standpoint and examples are given to illustrate the effect of different heat-treatments.

C. O. B.

1054. *Heat Treatment of Steel Forgings.* **H. H. Ashdown.** (Inst. Mech. Eng., J. 4. pp. 225–235; Disc., 236–302, March, 1917. Engineering, 103. pp. 266–270; Disc., 262–265, March 23, 1917. Mech. Eng. 39. pp. 250–252, March 30, 1917. Abstract.)—Deals with the subject of the heat treatment of steel from a works' point of view and illustrates the various points discussed by means of photomicrographs.

The subjects dealt with include pyrometers, sand annealing, oil-quenching, quenching baths, specifications, and ghost lines. C. O. B.

1055. *Iron-Carbon-Silicon Alloys* **J. H. Andrew.** (Iron and Steel Inst. Carnegie Schol. Mem. 7. pp. 1–17, 1916.)—The author has made a thermal and microscopical examination of a number of cast irons containing varying proportions of carbon and silicon. His results indicate that carbide of iron is unstable below 700° C. and slowly breaks up into alpha iron and free carbon. Since carbide of iron is stable in solution above 700°, two equilibrium diagrams are necessary, one for heating and one for cooling. These are reproduced and discussed. In a high-carbon Si alloy the first phase to separate is a silico-carbide of iron. The $Ar3{\cdot}2$ point is very persistent, even in high-silicon alloys, but 4·5 % Si is sufficient to entirely eliminate $Ar1$.

The paper is illustrated by fifteen photomicrographs. F. C. A. H. L.

1056. *A Bibliography of Alloys.* **C. Estes.** (Met. and Chem. Eng. 16. pp. 273–282, March 1, 1917.)—The author has drawn up a chart which includes all the binary systems of metals investigated up to Jan. 1, 1917. A list of references to the literature of each system is given. Tables of the

literature of ternary systems and quaternary systems are also included, as also is a list of papers dealing with the allotropy of metals. F. C. A. H. L.

1057. *Structure of Inhomogeneous Liquid-crystals.* **O. Lehmann.** (Ann. d. Physik, 52. 5. pp. 445–477; 527–540, and pp. 541–552, June 7, 1917.)—Three further contributions dealing with the structure of the peculiar bodies claimed as liquid-crystals by the author. The first paper deals with certain inhomogeneities which occur when the "crystal" lies up against anisotropic solid surfaces, giving rise to a screw-like structure and to "threads" and, further, to a ring-fence surrounding the latter. The second paper deals with the alteration in structure caused by admixture; while the third investigates the apparent rotations caused by the continuously proceeding wave-like alterations in structure. [See Abs. 408 (1916).] L. H. W.

1058. *Orientation of Liquid Anisotropic Salts of Cholesterine and of Oleates on Crystals.* **F. Grandjean.** (Comptes Rendus, 164. pp. 636–639, April 23, 1917.)—The author has studied the caprinate and benzoate of cholesterine, and the ammonium and trimethylammonium oleate on the cleavage surfaces, or in the fissures of cleavage of various crystals. In almost all cases the axis of the liquid placed itself normal to the support, as when placed on glass; and if sometimes it placed itself parallel to the surface, its direction was quite irregular and without relation to the crystalline support. In the case of cholesterine caprinate, however, quite definite orientations, parallel with the surface, were observed, with the positive liquid phase of that salt. [Compare Abs. 811 (1917).] A. F.

1059. *Coefficient of Diffusion of a Salt at a Definite Concentration.* **A. Griffiths.** (Phys. Soc., Proc. 29. pp. 159–161, April, 1917.)—In the calculation of the coefficient of diffusion by B. W. Clack, a simple relation is assumed between the density of a solution of a salt and the concentration. This simple relation is only approximately correct, and compromises are made which require justification. The author suggests a method of calculating the coefficient of diffusion which, to a high degree of theoretical accuracy, gives values for the coefficient that are independent of a precise relationship between density and concentration.

The method of calculation adopted by B. W. Clack is justified. L. H. W.

1060. *Concentration Element and Brownian Motion.* **P. Debye.** (Phys. Zeits. 18. pp. 144–148, April 1, 1917.)—A mathematical discussion of the subject. E. H. B.

1061. *Measurement of Oxidation Potentials at Mercury Electrodes.* II. *The Chromic-Chromous Potential.* **G. S. Forbes** and **H. W. Richter.** (Am. Chem. Soc., J. 39. pp. 1140–1148, June, 1917.)—Pure violet $CrCl_3$, partially reduced to $CrCl_2$ by purified hydrogen at 400° in quartz, was dissolved with stirring in ice-cold 0·1 N-hydrochloric acid. The solution, filtered into the cell, was allowed to stand over pure mercury. If all operations were conducted in hydrogen, or CO_2 absolutely free from oxygen, the potential rose throughout two days to a constant maximum, otherwise it fluctuated irregularly. Concentrations at equilibrium were determined analytically. Referred to normal hydrogen electrode as zero with correction for junction potentials, $\pi = -0{\cdot}400 + 0{\cdot}065 \log Cr^{III}/Cr^{II}$. On platinum, potentials reached a maximum about 0·16 volt lower, with evolution of hydrogen. [See Abs. 141 (1915).] A. F.

1062. *Structure of Electrolytic Copper.* **A. Sieverts** and **W. Wippelmann.** (Zeits. Anorg. Chem. 93. 3. pp. 287–310, Nov. 11, 1915.)—The continued experiments [see Abs. 497 (1916)] were made with specimens from the Langbein-Pfanhauser, Elmore, and other works. The ordinary electrotyping bath contains about 220 gm. of $CuSO_4$ and 20 to 30 of H_2SO_4 per litre, and is worked at up to 0·02 amp./cm.² at rest, or 0·03 amp./cm.² when agitated; when the baths are more concentrated, but contain less acid (7 or 8 gm.), and higher densities are used, the process is called rapid galvanising; the Pfanhauser works use a highly soluble copper salt (solution of 45 % Cu) at 0·4 amp./cm.². The hardness tests (scratching, after Martens) did not give the same results on repetition after a few months; the lower (kathode) surface is especially sensitive as to hardness to small variations in the conditions; the hardness increases with increasing fineness of structure. The deposits are always crystalline, the growth being perpendicular to plane surfaces; on irregular surfaces the crystallites are inclined and intersect in seams. In general it is believed that the higher the current density, the finer the structure; on the other hand low-current density is recommended for preparing blocks for banknotes, etc., and the upper (bath) surface is irregular with high current density. Rapid deposition yields coarse and thick crystals and irregular deposits. When a burnishing tool (agate, Elmore) is used, etching (with 1 gm. of copper ammonium chloride to 12 of water and ammonia, washed with water, ammonia, and alcohol) reveals layers parallel to the kathode surface; but this lamination is noticeable also when burnishing is not applied, and is partly due to the periodic emergence of the rotating surface from the bath. The paper was written by Sieverts—Wippelmann having been killed in the war—who was not then aware of the similar work of M. v. Schwarz. [See Abs. 1303 (1916).] H. B.

1063. *Silver Voltameter.* **J. Obata.** (Math. Phys. Soc. Tōkyō, Proc. 9. pp. 129–140, May, 1917.)—Experiments were first made with the object of explaining the cause of the decrease of the mass of the deposit when minute traces of acid are present in the electrolyte. On two platinum bowls, using a Smith form voltameter, silver deposits of about 2 gm. were made from the same electrolyte. After washing, drying, and weighing the deposits, the bowls were allowed to stand filled, one of them with neutral conductivity water and the other with the same water acidified to a certain strength with pure nitric acid. The only conclusion that can be drawn with certainty is that, whatever the surface condition of the silver may be, the acidified water dissolves a much larger amount of silver than the neutral water, so that corrosion of the deposited silver may at least be one of the causes of the action of acid on the mass of the deposit. Further experiments were made with a solution of silver perchlorate as electrolyte. The mode of preparation of the salt is fully described and comparative tests were made with solutions of the nitrate. The deposit from the perchlorate is finely crystalline, non-striated and extremely adherent, so that washing is very easy. Very good agreement was obtained between the masses deposited from perchlorate and nitrate solutions, but the acidity effect is much less marked in the perchlorate voltameter, the nature of the deposit making it more resistant to the effect of perchloric acid. An arrangement for magnetic stirring is also described, this being a device to prevent the loosening of the deposit. [See Abs. 960 (1914).] F. E. S.

1064. *High-temperature Heat developed during Electrolysis.* **C. Hering.** (Am. Electrochem. Soc., Trans. 30. pp. 347–351; Disc., 351–356, 1916. Met.

and Chem. Eng. 15. pp. 454–455, Oct. 15, 1916.)—When the current density on a kathode immersed in certain aqueous electrolytes is increased sufficiently, the kathode becomes red-hot, and may even melt. The author has studied this phenomenon, using small slips of thin sheet iron as kathodes, a lead anode, and an electrolyte of sulphuric acid of about 1·2 specific gravity. Current densities and voltages were observed during the gradual immersion or withdrawal of a kathode and the phenomena observed are described in detail. T. S. P.

1065. *Protection of Iron by Electroplating.* **O. P. Watts** and **P. L. De Verter.** (Am.Electrochem. Soc., Trans. 30. pp.145–155 ; Disc.,156–158, 1916.) —The experiments of the authors confirm the view that the superiority of electro-galvanising over deposits of other metals for the protection of iron is due to voltaic action. It is shown that thin electro-deposits of Zn, Cu, Ni, and brass are full of holes, and therefore only the first may be relied on to prevent rusting, unless deposits are made much heavier than is at present the rule. Deposits of Ni should exceed 0·0015 in. (0·038 mm.) in thickness in order to protect iron out of doors, and copper or brass plate should have three times this thickness; even then it is not certain how long such coatings will afford protection. For the protection by electroplating of iron which is to be exposed to the weather, zinc (or cadmium) is the only metal worthy of consideration. The experiments do not show that double coatings (zinc followed by copper or brass) are distinctly superior to a single heavy coating of the latter metals. If zinc is to be used advantageously, it should form the outer coating. T. S. P.

1066. *Current Efficiencies in Nickel Plating with Rotating Kathodes.* **F. C. Mathers** and **E. G. Sturdevant.** (Am. Electrochem. Soc., Trans. 30. pp. 135–144, 1916.)—In nickel-plating baths, low initial current yields are obtained with stationary kathodes and still lower yields with rotating kathodes. The authors show that these effects are due to the impurities which are present in the nickel salts. It is further shown that free mineral acid can produce this lowering of the yields, but this is not the primary cause, since the neutralisation of the baths by boiling with nickel hydroxide does not overcome the trouble. The yields from baths electrolysed continuously with rotating kathodes started low but reached values of about 97·6 % in, 2, 4 and 5 hours respectively for baths of 100, 200, and 300 cm.^{3} made from commercial nickel salts. Similar baths made from purified salts gave yields of about 98 % for the first hour, regardless of volume, indicating that impurities present are the cause of the diminished yields. The yields with stationary and with rotating kathodes are approximately equal in all cases where the baths are sufficiently pure. Nitrates lowered the yields more than any other impurity that was tried. Ferric salts, ammonium citrate, or ammonium acetate lowered the yields, but ferrous sulphate up to 2 % was almost without effect. Free boric acid lowers the yields somewhat when present in quantities greater than 2 %. T. S. P.